

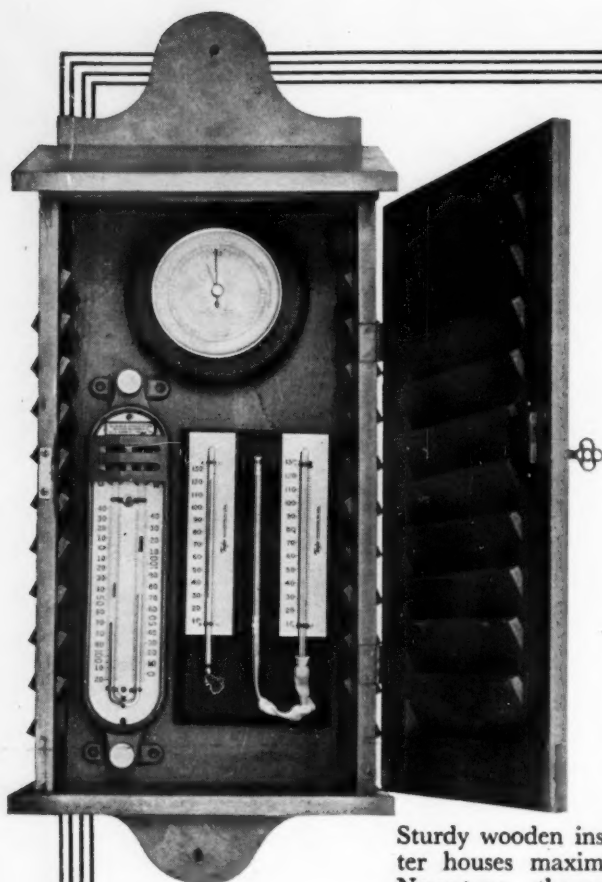
DECEMBER 1950

THE SCIENCE TEACHER



- A Jet Model That Works
- Next Steps in Evaluation
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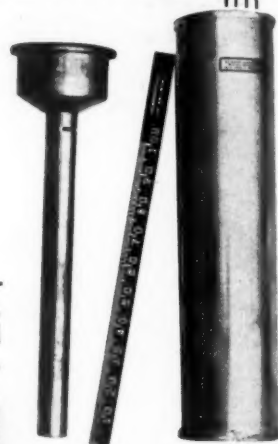
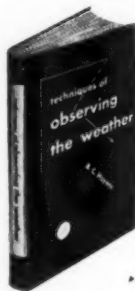
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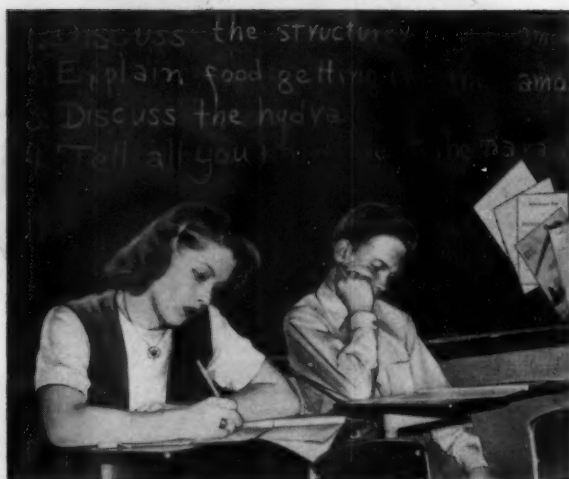


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THIS MONTH'S COVER. Tests seem to be a necessary part of science instruction. If the students in the picture are trying to answer questions like those on the blackboard, their perplexity is understandable. How much of an improvement are the booklets of objective tests? The first two articles in this issue of *The Science Teacher* offer helpful suggestions for new techniques and emphases in evaluating the results of instruction. And the biology teacher at Montgomery Blair High School, Silver Spring, Maryland—where the picture was made—assures us that her students **do not** get questions like those on the blackboard! Photo: Winn Studio, Silver Spring, Maryland

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Guided Missives

Editor, *The Science Teacher*:

In the April issue you published an article by B. J. Stern on the "Interrelation of Human Heredity and Environment." This article was not simply a discussion of a controversial subject but specifically accused me of various mistakes and objectionable practices. I would, therefore, be very grateful to you if you would publish in an early number the enclosed reply to Professor B. J. Stern.

CURT STERN

Professor of Zoology

University of California, Berkeley

In the chapter on "Selection and Eugenics" of my book *Principles of Human Genetics* (W. H. Freeman & Co., San Francisco, 1949) the weighing of the evidence has led me to reach the tentative conclusion that there are genetic differences in the mean intellectual endowment of the different socioeconomic levels. No certainty regarding this conclusion has been claimed in any of the various formulations to be found in the relevant pages of the book.

Professor Bernhard Stern's critique rests essentially on his statement that "recent detailed investigations . . . by Davis, Havighurst, and their coworkers have proved *unequivocally* that the differential scores of persons when classified according to the occupations of their parents are explicable *entirely* in terms of the nature of the tests themselves" (*italics mine*). The data presented by Davis and Havighurst do not warrant as sweeping a statement as this. These authors have shown, more vigorously than before, that cultural, i.e., environmental factors, play a significant role in the test scores of socioeconomic groups, but there is nothing in their studies that enables one to state unequivocally that no genetic component is present in addition to the cultural. Davis and Havighurst (*Scientific Monthly*, 1948, 67, 313) themselves, in replying to criticisms by A. S. Otis (*Scientific Monthly*, 1948, 67, 312), write ". . . he says that we assume that all socioeconomic groups are equal in innate intelligence. This is stating our position a little more strongly than we would do; we would rather say that in view of what is now known about genetics and about intelligence testing, the safest *assumption* is that the several socioeconomic groups in the United States are equal in innate intelligence. *We cannot prove* this on the basis of evidence at present available . . ." (*italics mine*).

The last sentence quoted in the preceding paragraph continues: ". . . but neither can the assertion that socioeconomic groups differ in innate intelligence be proved with evidence now at hand." I agree with this statement if emphasis is placed on the word "prove." It is, however, legitimate to look at the totality of evidence already at hand and to attempt an evaluation which, of course, is subject to change when new evidence has accumulated. After going over a considerable body of evidence of which only a limited amount, selected as representative, has been cited in my book, and not having started with a preconceived opinion, I found it indeed "hard to avoid the conclusion . . . that there *are* mean differences in the genetic endowment of the different socioeconomic groups."

The SCIENCE TEACHER

THE SCIENCE TEACHER

Journal of the
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Bernhard Stern's specific criticisms are: (1) that I have ignored Osborn's recognition of "the many weaknesses of the studies themselves"; (2) that I have paid no attention to a "warning" by Osborn according to which testing of preschool children "is not so valid as for the school years"; (3) that I did not realize that infant mental tests in 1938 were of doubtful value; and (4) that after initial use I have "abandoned" certain data from Russia "as unsatisfactory." Some of these criticisms might be valid if I had expressed an unequivocal opinion rather than one couched in terms of probability. But the way in which the opinion was expressed is witness of my awareness of debatable aspects of the evidence. Moreover, *ad* (1), Osborn's comment regarding "the many weaknesses of the studies themselves" was not made when he drew his conclusion as to the probable *existence* of innate differences between socioeconomic strata but when he discussed the problem of estimating relative to environmental differences the *size* of such a difference. Again, *ad* (2), his footnote regarding the testing of preschool children has no implication of a "warning" and refers not to the *fact* of differences but to the numerically somewhat different scale of scores from preschool as compared to older children. In principle, differences in the same direction were recorded for both young and older children of different socioeconomic groups. *Ad* (3), that infant mental tests in 1938 were of doubtful value, it may be replied once more that the unsatisfactory nature of these tests concerns rather their exact quantitative aspects than the qualitative establishment of test differences. Finally, *ad* (4), Bernhard Stern's reference to my having abandoned certain data as unsatisfactory is inadmissible. The data may be found on page 516 of my book, neither abandoned nor called unsatisfactory.

My interpretation of the evidence, contrary to a claim made by Davis and Havighurst, is fully compatible with our knowledge of human genetics. These authors say:

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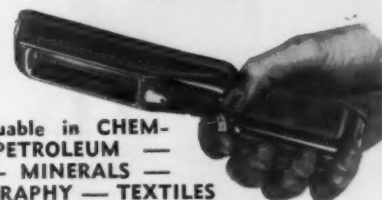
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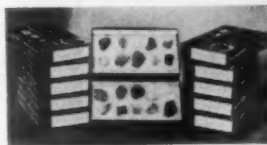
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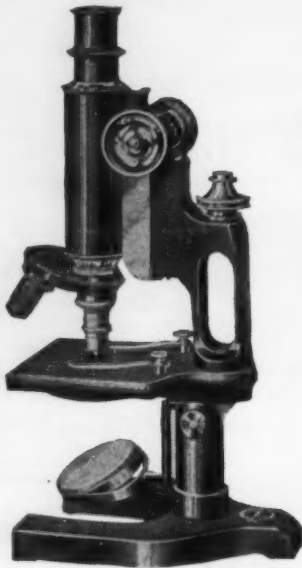


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"From what is known about genetics, the children of a man who was well favored with innate intelligence would have very little chance of being better favored than the children of a man who was less well endowed genetically in these respects." This statement is based on the arguments that "both men carry many latent characteristics as well as manifest ones" and that their wives contribute half the genes to the offspring. But these facts bear only on the *degree* of heritability, not on the genetically expected existence of heritability. Given the premises made by Davis and Havighurst of the existence of men favored with innate intelligence and of others less well endowed, genetic knowledge leaves no doubt that, on the average, the children of the former are again innately more favored than the children of the latter.

To conclude, it is one thing to express an opinion on the weight of scientific evidence and another to draw practical conclusions from one's judgment. I have pointed out repeatedly the preliminary nature of the conclusions reached, their limited eugenic significance, the lack of urgency of the eugenic problem, and the importance of the environmental component. Censure of my judgment as manifesting "conventional biases" seems based primarily on the potential sociological misuse of such judgment. Censure of this kind is contrary to the essence of free inquiry and implies a desire to impose doctrinal limitations to the study of observable phenomena. We must be free, however, to reach conclusions, regardless of the misuse to which they may be subjected. In the condemnation and combat of their misuses we all can join hands.

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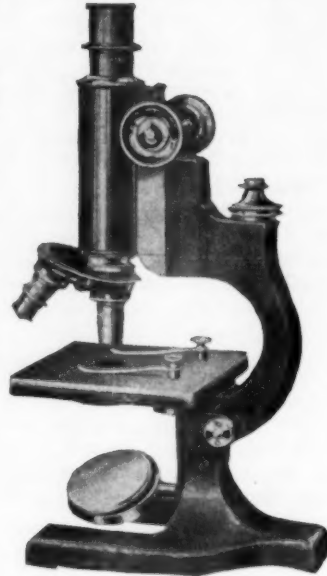
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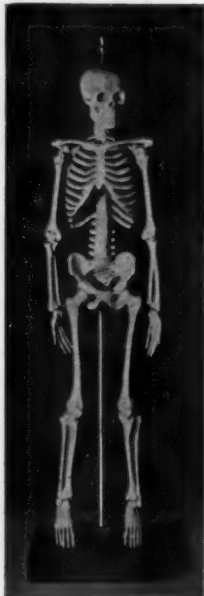
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THE SCIENCE TEACHER

Vol. XVII, No. 5

December, 1950

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The National Science Teachers Association is a Department of the National Education Association and an Affiliate of the American Association for the Advancement of Science. Established in 1895 as the NEA Department of Science Instruction, the Association later became the American Council of Science Teachers. It merged with the American Science Teachers Association and reorganized in 1944 to form the present Association, and **The Science Teacher** became the Official Journal of the new National Science Teachers Association.

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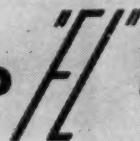
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Editorial

"SINCE WARS BEGIN in the minds of men, it is in the minds of men that the defenses of peace must be constructed. . . ."

It was on the basis of this principle that the United Nations Educational, Scientific and Cultural Organization (UNESCO) was established—to use the all-important channels of education and the sciences and the arts to bring messages of international understanding to the minds of men and stimulate cooperation toward peace and security.

It was upon this same basis that the National Research Council, like its fellow organizations in other lines of endeavor, established its Committee on UNESCO, which met this September to discuss major needs for international cooperation in the sciences, developed a program for a scientific and technical training center in Korea, and passed its proposals on to the U. S. National Commission and via it, eventually, to UNESCO itself for action.

The "S" in UNESCO is, of course, for *science* and the contributions which science can make to international harmony by creating the basic material living conditions necessary for peace and friendship to thrive. In this area the science teacher is a force for international peace merely by disseminating the information and helping to develop the skills necessary for raising living standards throughout the world.

But the "E" of UNESCO is for *education*; and science teachers are not only scientists but *educators*. In this area the general task is one of ensuring that instruction conveys and inspires and stimulates the attitudes and the *spirit* of international understanding.

The natural sciences *can* be direct and meaningful tools in the creation of attitudes for peace:

First, because implied in the scientific approach to the physical world are the same rationality, the same openness to new concepts and additional possibilities, which are necessary in order for the people of a nation to understand and accept other, foreign cultures. Thus science contains a *philosophy* for international cooperation.

Second, because science has thrived, and can only thrive, on the interchange of ideas and techniques; on mutual cooperative effort, based on commonly accepted principles, directed toward a common goal. Thus science can be a *case study* in international cooperation.

Third, because science, as a relatively objective and universally necessary field, can provide an opportunity for joint efforts by nations which could never be attempted with success at the more political level. Thus science can provide a *workshop* in international cooperation.

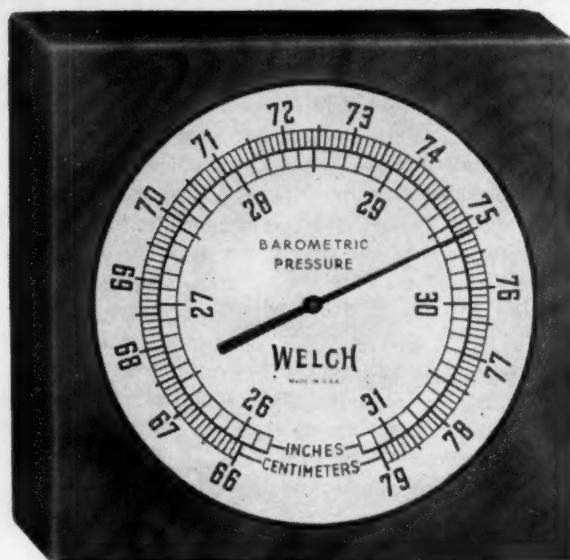
But how may the individual teacher bring these real relationships to life for the young minds in his own classrooms? In teaching *science* he can: (1) emphasize the different origins of the great contributors to science, the many different countries whose cultures each produced something valuable to scientific progress; and (2) encourage cooperation in scientific projects among possible diverse cultures represented in his own class.

In teaching *about* science he can present it and encourage its conception: (1) as a rational approach to living, requiring a free mind, an openness to change, and to progress through new ideas; (2) as an example of real, constructive intercultural exchange, to the large extent to which science has been just this; and (3) as an opportunity—to the extent that science has not done so to date—to exchange with Asia and Latin America our advanced techniques and technology for other, different but valuable products of civilization.

Admittedly this outlines a rather staggering concept of a teacher's potential contributions to UNESCO and its objectives. Yet it is believed that most teachers will not resent the challenge—if UNESCO will do its part.

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Next Steps in Evaluation

By **GEORGE W. ANGELL**

Dean, New Paltz State Teachers College, New York

and

WILLIAM W. RASOR

Instructor, Science Education, New Paltz State Teachers College

Here is a three-star article: one star for suggesting that all, or at least many, of the objectives of science instruction appear frequently in our tests and examinations; two stars for suggesting that evaluation and teaching frequently should occur simultaneously; three stars for an account of practical experience in seeking these two worthy goals.

AN EIGHTH-GRADE science teacher was determined to help young people learn the methods of science. Through short discussions and examples he had been assisting students in identifying and questioning a variety of dogmatic statements made by various members of their group. The students had listed a number of things which they believed as true. They had previously discussed the meaning of such terms as facts and superstitions. Facing the pupils now was the problem of determining which of their beliefs were sound and which were not. Which of these simple beliefs could be supported by facts or by experimental evidence?

These pupils had not yet participated in activities specifically designed to develop an understanding of the experimental method. In order to set the stage for a discussion which would acquaint them with fundamental concepts involved in experimentation, the instructor had decided to start the class hour with a short quiz. This quiz, consisting of three items taken from the previous year's final examination, was presented to the students in the following form:

Many of us disagree on the statements we have read and discussed. Some of us believe the statements to be true and others of us believe the statements to be false. One way to determine whether or not the statement is true or false is through experimentation.

John, Mary, and Carl suggested the following experiments in order to gather evidence to determine the truth or falsity of the statement: "The chewing of gum cleans the teeth."

Will the experiment suggested by John, Mary, or Carl enable us to decide the truth or falsity of the statement?

Directions:

A. Quickly read the experiments suggested by John, Mary, and Carl.

B. After reading the three experiments, reread John's experiment and put an "X" in the box labeled YES if you believe John's experiment will enable us to decide the truth or falsity of the statement. If you do not believe it will enable us to decide, put an "X" in the box labeled NO.

C. After you have finished marking the experiments, reread each experiment and tell why you decided it should be marked either YES or NO. Your statement should be well written. Use brief sentences that are very easily understood. Be sure to tell all of your reasons for saying either YES or NO.

John's Experiment

Select at random 20 people and ten judges to participate in the experiment. Divide the 20 people into two groups, A and B. Have the judges examine the teeth of the 20 people to determine cleanliness and then have the judges pass out gum to each of the people. Have the 20 people chew gum for two hours. Have the judges examine teeth at the end of two hours to determine if the gum chewers have cleaner teeth.

Mary's Experiment

Select at random 20 people and ten judges. Have the judges examine the teeth of the 20 people to determine the whiteness of the teeth. After the judges have left, equally divide the 20 people into two groups, A and B. Have one group chew gum for two hours. Have the judges come back in at the end of two hours and again determine the whiteness of teeth to see if gum chewers' teeth became whiter to a greater extent than those of non-gum chewers.

Carl's Experiment

Select at random 20 people and ten judges. Equally divide the people into two groups, A and B.

After the judges have left, have one group chew gum for two hours. Have the judges come back in at the end of two hours and compare the cleanliness of teeth of gum chewers and non-gum chewers to see if those chewing gum had the cleaner teeth.

After the pupils had responded to the quiz items the papers were collected, and the discussion which ensued is partly recorded here.

Richard: "I don't think any of the experiments were any good because gum does more damage to the teeth than good."

Norman: "I think the same thing because sweetness of gum causes a coating on the teeth and causes the teeth to decay."

Robert: "Most judges can't remember how clean the teeth were before they left the room."

Robert: "The judges had to remember whose teeth were cleaner, and if they were biased they would not judge fair."

Dick: "Judges don't know what is going on when they come back to see what teeth are the cleanest. Just tell them to examine the people, then let them out of the room. When they come back let them examine the ones who have chewed the gum and those who haven't to see who have the cleanest."

Richard: "If you have white teeth or have a film on them, just chewing gum for two hours won't change them. They will stay the same."

Teacher: "Chewing of gum does what?"

Group Answer: "Cleans teeth."

Teacher: "Are we trying to decide if chewing gum is good for the teeth?"

Joan: "No."

Teacher: "What is it we are trying to decide?"

Allen: "Whether it cleans the teeth or not."

Teacher: "Richard, do you remember what you said in the beginning about the experiments?"

Richard: "None of the experiments were good because chewing gum is not good for the teeth."

Teacher: "Could we use that for saying the experiments are not any good?"

Group Answer: "No."

Teacher: "Norman says sweetness causes the decay. Does this enter in the judgment of whether or not these experiments are good?"

Ralph: "We want to find out if they are clean."

Teacher: "If a tooth is decayed does it mean the tooth is not clean?"

Norman: "Not necessarily; clean teeth can be decayed."

Teacher: "I wonder if we can see the fact that chewing gum may or may not cause teeth to decay? Would that have anything to do with our experiment?"

Robert: "It would not right away."

Teacher: "We are looking for what in the experiment?"

Norman: "Whether gum cleans teeth."

Teacher: "What do you think is right and what is wrong with John's experiment, if there is anything right or anything wrong?"

Ted: "Judges would have to remember how the people's teeth look because you really couldn't tell unless you had something to compare them with."

Robert: "Even if you had half of the group chew gum, still two peoples' teeth wouldn't be the same, and you would still have trouble."

Dick: "The judges should not know anything about it."
Robert: "Judges might be biased and would not give a good judgment."

Richard: "Let one judge pass out the gum and take all the other judges out of the room."

Teacher: "Do you think Richard and Norman would make the best judges for this? Would Richard and Norman be good to use in John's experiment?"

Ted: "No, because they don't think it is any good to begin with."

Teacher: "Do you, Richard, think you would be a good judge?"

Richard: "No, I would favor the ones without the gum in the first place."

Norman: "I feel the same way."

Teacher: "Why would Norman and Dick favor the people who did not chew gum?"

Group Answer: "Because they don't think gum is any good for the teeth."

Teacher: "Do you think John's experiment is the best?"

Robert: "The experiment would be the best one if the judges were in the next room. There isn't any experiment where the judges don't know who is chewing gum."

Teacher: "Let's look at all experiments to see if any of them have the judges in the next room where they don't know who is chewing gum."

Teacher: "Does everyone know who is chewing gum in Mary's experiment? What about the judges, Ralph, did they know anything about the chewing gum?"

Ralph: "They were out."

Teacher: "Shall we mark Mary's experiment 'yes'?"

Group Answer: "Yes."

Robert: "If the judges guess which had been chewing gum all right, it would prove it was right, but if they guessed some wrong, it would prove the experiment wasn't right."

Teacher: "Would that prove the judges guessed?"

Dick: "The judges are telling the truth."

Laura: "A dentist would make a good judge."

Teacher: "Why, Laura?"

Laura: "He knows about the teeth."

Robert: "The dentist would know the answers."

Teacher: "Would the dentist be a good judge?"

Robert: "The dentist might not like chewing gum and would talk against it."

Teacher: "What is a judge supposed to do in this case?"

Dick: "Just examine them and tell which ones got cleaner or just stayed the same."

Teacher: "What does the judge do?"

Robert: "He examines them again."

Teacher: "What for?"

Robert: "He judges which one has the cleaner teeth."

Smitty: "He finds out which ones have changed the most."

Teacher: "What does he mean by changed the most?"

Group Answer: "The teeth have become cleaner."

Teacher: "How can we get around the idea of just remembering it?"

Robert: "Give him a rating."

Teacher: "How could we find out if our teeth are clean?"

Robert: "If we have a film on them."

Teacher: "How can we find out if our teeth have a film on them?"

Patricia: "If they are yellow."

Teacher: "Tell us why John's experiment would be 'Yes' or 'No'."

Robert: "John's would be 'No', but Mary's 'Yes'."
 Teacher: "Why is John's experiment 'No'?"
 Robert: "The judges are relying on remembering whether or not the teeth were clean in the beginning."
 Teacher: "How would you mark John's experiment?"
 Group Answer: "No. The judges could not remember who had the clean teeth."
 Smitty: "They could have written them down."
 Dick: "Have a chart for each person to see what their teeth are like if they are clean."
 Teacher: "Does the color of teeth tell whether or not they are clean?"
 Richard: "To an extent."
 Teacher: "Does the color tell us or could any teeth be white but still be dirty?"
 Joan: "Teeth can be white but still be dirty. Judges should use something besides color."
 Teacher: "Does it affect it if they send judges out of the room?"
 Norman: "It is the same thing."
 Allen: "In Carl's experiment judges did not examine people's teeth before leaving the room."
 Teacher: "Does that make a difference? How?"
 Donald: "If the judges did not examine the teeth, they don't know whether they were clean or dirty when they started."
 Teacher: "Do you think we might give better reasons for our answers if I let you take the test again?"
 Group Answer: "Yes."

At this point the instructor passed out a new set of quiz papers, and the pupils recorded their latest thinking before the bell rang.

In planning for the next class session the instructor completed the following preparations:

1. A careful examination of each student's pre-test was made to determine whether or not he had been able to select and express any of the seven reasons why the various experiments were inadequate for testing the criterion statement. It was discovered that 12 students had been unable to formulate any correct reasons for the inadequacy of the experiments. Eight students had been able to formulate one correct reason, and two students had been able to formulate two of the reasons. Upon comparing responses to the pre- and end-tests, it was further discovered that there were not only certain distinct gains, but also much repetition of errors, and, in a few instances, individual students actually made poorer responses on the end-test than they did on the pre-test.

2. An overall analysis of the pre- and end-test results identified those areas which would need further clarification and discussion before students were asked to participate in the actual activity of designing and completing purposeful experiments. For example, this analysis indicated that not one student had recognized a glaring weakness in Mary's experiment. They had failed to discriminate between the terms cleanliness and whiteness

of teeth. They seemed perfectly willing to accept a measure of whiteness as a test for cleanliness. Furthermore, only three students had gained in ability to identify the lack of controls in John's experiment. On the other hand, a sharp rise was registered throughout the class in the ability to identify the lack of a pre-examination in Carl's experiment. One of the most interesting results of the analysis indicated that several students who had marked on the pre-test that Mary's experiment would not adequately test the criterion statement changed their opinions and made an incorrect response to this item on the final test.

The analysis further revealed the fact that only one or two students in the entire class had recognized such important points as, (1) the bias of judges and how to control it, (2) that the two-hour period for chewing gum was possibly inadequate to test the hypothesis, (3) that a group of 20 might be too small a sample, and (4) that judges should be selected on the basis of competency.

3. On the basis of the above preparation the instructor was able to make specific plans for continuing the discussion in such a way as to bring out specific points which had not been adequately clarified in the previous discussion.

4. Since this particular instructor intentionally planned the discussion so as to emphasize student contributions and to minimize the "teacher-telling" process, it was highly important for him to analyze the actual class discussion in order to organize specific steps for improving his ability to guide future discussions in a manner which would help students arrive at accurate conclusions and reasons. The preceding analysis of the changes in pupil reasoning confronted the instructor with a number of problems:

- (1) Why had no student been able to discern the weakness in Mary's experiment? An analysis of the discussion clearly reveals that, although the factor of color was brought into the class discussion at several points, at no time did the instructor pursue the point until its meaning had become clearly identified with Mary's experiment. Furthermore, no student clearly pointed out that whiteness was not necessarily a measure of cleanliness, although Joan came close to it when she said, "Teeth can be white, but still be dirty. The judges should use something besides color."

- (2) On the pre-test, four students used, as a reason for marking one or more experiments as inadequate, statements similar to the following: "Judges could not *remember* how the teeth looked at the beginning." This particular reason was con-

sidered inadequate by the instructor since there was nothing in any of the experiments that indicated that the judges had to remember the results of their first examination. Nevertheless, on the end-test 12 students used this type of reasoning. Why this shift to a reason which the instructor considered inadequate? An analysis of the discussion clearly revealed that the teacher attempted to point out through questioning that the judges did not need to rely on remembering whether or not the teeth were clean in the beginning. That he was not successful is indicated by the fact that there seemed to be a group fixation concerning John's experiment when they mimicked Robert's response, "The judges are relying on remembering whether or not the teeth were clean in the beginning." This fixation was not decisively refuted in the ensuing discussion which pointed out that the judges could have written or charted the results of the pre-examination.

This was obviously a weak spot in the discussion since the students were allowed to settle on a reason which the instructor considered inadequate and, in the process, tended to overlook the need for more adequate controls in John's experiment.

(3) Why did several students change their opinions and mark on the end-test that Mary's experiment was adequate for testing the statement? This also was contrary to the desire of the instructor. Again, an analysis of the discussion showed that the instructor allowed the group to focus on the incorrect response when he said, "Shall we mark Mary's experiment 'Yes'?" Immediately, the group responded, "Yes," and the subsequent discussion never quite refuted this fixation.

Summary

The above discussion is an authentic recording of an actual classroom situation in which an instructor was practicing the next step in evaluation: that of making it part of the teaching-learning situation on a daily basis. Far too often teachers think of examinations as necessary evils to be given only at the end of certain time periods and for the specific purpose of assigning grades to students. Some of the salient features brought out in the foregoing discussion are as follows:

1. Testing materials must be given at the beginning, as well as at the end, if the teacher is concerned with *changes in behavior*.

2. Using test materials as a springboard for class discussion helps both the students and the

teacher to focus their activities on specific objectives.

3. Having each student spend a short time at the beginning of the class to become personally involved in making written decisions helps to create within each individual a personal challenge to defend those decisions, and thus encourages a large number of students to participate actively in the discussion.

4. The procedure of using informal test materials in the classroom helps the students to become acquainted with the objectives of the course as they will eventually be revealed to them through formal examinations. How often students have complained that failure in a course has been largely due to unfair examinations which were not clearly emphasized in the class work! Any thoughtful college student will tell us that, regardless of what a professor might say are the objectives of a given course, the practical objectives for the student are seldom more clearly revealed than when he takes his first examination in the course. Why not use test items from time to time as a way of introducing new objectives and new units of work in the classroom?

5. Using short quizzes helps to provide a continuous record of individual student achievements, errors, and changes in behavior. These types of materials should not be filed for teacher use only but should find their way back to the individual pupils, placing in their hands irrefutable materials which may form the basis for their personal plan of improvement.

6. An analysis of the quiz results can give the teacher a down-to-earth picture portraying those steps which must be taken in the succeeding class meetings.

7. Tests, properly designed, may enable the teacher to anticipate or predict the relative difficulty of attaining identified objectives.

8. Probably one of the most important outcomes of such evaluation techniques, yet one of the activities least often pursued by teachers, is that of improving the instructor's teaching techniques. This situation was one in which the instructor was devoted to a discussion technique based on active thought by students rather than inactive listening to correct answers as provided so often by the lecture method. The recording of the class discussion, however, clearly revealed that such a technique is most complex and needs careful study if a teacher is to become effective through its use. In this particular situation the instructor

(See EVALUATION page 241)

Constructing Machine Scorable Examinations in the Natural Sciences

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THERE APPEARED in another journal some time ago an article by Englehart¹ in which he reported many suggestions of value in adapting to the limitations of machine scoring examinations. In addition to general suggestions regarding the form and arrangement of the items in such examinations he reported some modifications that would tend to increase the scope and function of such examinations. For example, he illustrated how true-false, true-false with supporting reason, multiple choice, and matching items could be prepared in scorable form. Englehart also showed how some specific learning traits could be incorporated in examination items. He presented techniques for composing items which emphasize performance in relation to such factors as chronological arrangement, comparison of magnitude, and interrelationships of magnitude.

It has been the experience of the author that these suggested modifications tend not only to aid in focusing items more sharply upon identifiable learning experiences but also to add variety to the examination procedure.

An examiner may try to build an examination so that each separate item occupies, as it were, a discrete position on a chart constructed with the objectives being examined ranged along one axis and the course content intended to achieve these objectives listed along the other axis. The availability of a wide range of forms for building items represents a third dimension against which each segment of course content and its related objective can be viewed to see how an item can be constructed in the most efficient manner.

This paper reports additional modifications of machine scorable examinations based on the implications of the preceding paragraph. The examples use information drawn primarily from the natural sciences. However, since the original ideas underlying each example have been gleaned from many areas, it is assumed that they may be adapted to

complement the learning experiences carried on in other subjects.

The performance of students in recognizing the members of a class may be observed by such an item as:

Example a. Blacken the appropriate space on the answer sheet to show which term does not share with the others a major science relationship.

- (4) 17. 1—Hanging valley. 2—Cirque. 3—Drumlins. 4—Tufa. 5—Moraines.
(5) 18. 1—Carotid. 2—Arterioles. 3—Aorta. 4—Aortic arch. 5—Jugular.

If the examiner wishes to provide more of a clue to the relationship involved in the classification, the item may take the form:

Example b. Blacken the appropriate space to show which pair of factors does not share a major science relationship with the other pairs.

- (2) 27. 1—Ammeter—Amperes. 2—Thermometer—Calories. 3—Shunted galvanometer—Amperes. 4—Photometer—Candle power. 5—Barometer—Millibars.
(4) 28. 1—Phloem—Sieve tubes. 2—Pancreas—Isles of Langerhans. 3—Blood—Leucocytes. 4—Lungs—Bowman's capsules. 5—Anther—Pollen grains.

Suppose we accept the thesis that our tests and examinations should cover many of the objectives of science teaching. How can we construct such examinations? How can we get at an estimate of students' abilities to recognize relationships? To identify examples of interdependence? To apply information and principles in novel situations? To recognize information pertinent to the approach of a problem? To obtain information from graphic data? And so on for many other identifiable skills and abilities.

In answer to these questions, John Woodburn has culled many practical suggestions and concrete examples from his five years' experience on the Board of Examiners at Michigan State College. It is our opinion that Dr. Angell's and Professor Woodburn's articles together can serve as a guide and handbook for test construction, effectively helping us to bring objectives, instruction, and evaluation practices closer together. Mr. Woodburn, like Dr. Angell, began as a high school science teacher in Ohio, then moved to Michigan State College. This is his second year at Illinois State Normal University.

¹ Englehart, Max D. "Suggestions for Writing Achievement Exercises to be Used in Tests Scored on the Electric Scoring Machine." *Educational and Psychological Measurement*, 7:357-374. 1947.

Familiarity with the sequence in which events occur may be measured by items of this type:

Example c. Blacken the appropriate space to show which event would occupy the fourth position if the following events were arranged in the order in which they occurred.

- (2) 37. 1—Publication of Einstein's theory of the equivalence of mass and energy. 2—Artificially induced radioactivity. 3—A controlled nuclear chain reaction. 4—Identification of isotopes. 5—Identification of natural radioactivity.
- (4) 38. 1—Priestley's discovery of oxygen. 2—Cavendish's discovery of hydrogen. 3—The experimental elaboration of Boyle's law. 4—The Declaration of American Independence. 5—Determination of the composition of water.

If it is desirable to introduce the ability to identify interdependence among the order in which events occur, an item may take the form:

Example d. For each of the following items blacken space

1. if the second event cannot occur unless the first has occurred or is occurring.
 2. if the first event cannot occur unless the second has occurred or is occurring.
 3. if either event may occur independently of the other.
- (3) 47. Rotation of the earth—Change of the seasons.
- (1) 48. Science—Current state of civilization.

A student's performance on an item of the basic true-false type is very difficult to analyze. This difficulty may be resolved at least partially by building qualifications into the item. An example is:

Example e. For each of the following items blacken space

1. if the statement is true and has been proved so by experiment or observation.
 2. if the statement is false and has been proved so by experiment or observation.
 3. if the statement is part of an accepted theory.
 4. if the statement contradicts an accepted theory.
 5. if the statement is true merely by definition of a word or words used.
- (5) 57. Air is a mixture.
- (1) 58. Mercury is the planet that is closest to the sun.

Another example of adaptation of the basic true-false item may take the form:

Example f. This group of items is based on three facts which have been observed regarding a certain phenomenon. Blacken space

1. if, based on evidence I, the statement is true.
2. if, based on evidence II, the statement is true.
3. if, based on evidence III, the statement is true.
4. if, based on evidence I, II, or III, the statement is false.
5. if no evidence is given in the three facts by which the statement can be judged.

Phenomenon: A series of sedimentary rocks which make up a cliff is characterized by having (I) an under-clay stratum, above which lies a thick coal seam, and on top of that a limestone stratum; (II) the sediments as they were originally laid down; (III) a normal fault cutting the stratum.

- (1) 67. The climate that prevailed during at least a part of the deposition was warm.
- (5) 68. The cliff was exposed by glacial action.

An adaptation similar to example "f" takes the form:

Example g. The following group of items is based on four science principles. Blacken space

1. if the statement violates principle I or II.
2. if the statement violates principle III or IV.
3. if the statement violates three of the principles.
4. if the statement conforms to all four of the principles.

Principle I. Matter is composed of small discrete particles.

Principle II. Molecular motion ceases only at a temperature of absolute zero.

Principle III. Atoms retain their identity while taking part in chemical reactions.

Principle IV. Atoms exhibit kinetic energy.

- (4) 77. Chemical reactions involve single or small groups of atoms.
- (2) 78. Neutrons may be a product of chemical reactions.

A modification of the true-false form that is intended to stimulate and permit a student to capitalize upon a more complex mental process follows.

Example h. For this group of items blacken space

1. if both statements are consistent and both true.
 2. if both statements are consistent and both false.
 3. if the statements are inconsistent; I being true and II being false.
 4. if the statements are inconsistent; I being false and II being true.
- (2) 87. I—In a streamlined flow of air, the greater the velocity of the air the greater the pressure.
II—In a flow of air through a constricted tube, the pressure will be greatest at the point of greatest constriction.
- (4) 88. I—In general, temperatures in the neighborhood of freezing destroy enzymes.
II—In general, temperatures in the neighborhood of the boiling point destroy enzymes.

The basic form of the matching type of item may be modified toward focusing the performance of the student in identifiable directions. At times an examiner may wish to observe a student's ability to apply information to novel situations. If a group of more or less homogeneous principles can be identified, such an item as follows may be constructed.

Example i. For the following group of items blacken the appropriate space to show which of the statements of information is most closely related to the observation described in the item.

1. The atmosphere is the place of disposal of carbon dioxide and the source of oxygen for practically all living things.
2. The rate of evaporation of a liquid is related to the concentration of vapor above the liquid.
3. The absorption of solar energy accompanies the loosening of some chemical bonds between atoms and the formation of bonds between other atoms.
4. If water is not taken up rapidly by the soil it runs off taking the rich top soil with it.
5. The atmosphere contains many inert materials that combine with other elements with difficulty.

- (3) 97. If a board is left lying on the lawn the grass under it will lose its green color.
- (1) 98. Eggs, although fertile, will not hatch if allowed to collect a thin film of oil before incubation.

This preceding type of item may be used to observe a student's performance over a wide range of ability to recognize relationships. The two examples cited may be considered of relative low difficulty. Item 97, for example, would require an identification of the relation between green color in plants and photosynthesis plus the relationship between photosynthesis and the energy processes which accompany it. In one instance when these two sample items were used, both showed a difficulty of 39 per cent with item 97 yielding an index of discrimination¹ of .22 and item 98 an index of .46.

Using this same list of information, another item was stated as, "Conservation officers know that if too deep a layer of snow is allowed to collect on the ice over lakes the fish in the lakes will die from lack of oxygen even though there are holes through the ice." In order for a student to answer this item correctly it is assumed that he will recognize the dependence of the fish on the plants in the lake for oxygen and the dependence of these plants upon solar energy for the maintenance of photosynthesis with the accompanying release of oxygen. This item revealed a difficulty of 83 per cent with only 17 per cent of the students agreeing with the choice of information number three as the correct answer; 31 per cent of the high sample of the students and 30 per cent of the low sample marked the first choice as the correct response. This would indicate a tendency to choose a response indicating an inferred superficial relationship.

A similar version of the preceding adaptation enables the examiner to observe the students' abilities to recall information that was developed through specific films, references, reports, demonstrations, or other classroom activities. The directions may be changed to read, "For this group of items you are given brief references to some demonstration given during the course. By recalling the observations and conclusions of the total demonstration blacken the appropriate space to show which demonstration provided the most information in accounting for the situation described in the items."

Adaptations of the basic matching type of item become useful when an examiner wishes to observe a student's performance in working through a complex procedure. It is assumed that this technique is applicable in any procedure which can be analyzed

¹ Graphic estimates of phi coefficient. Sub-groups drawn from the high and low quartiles of the total test score distribution.

into component factors. The aspects of procedure most evident in the situations in which scientists have been or are working are used here as an illustration.

The first factor is related to the ability to recognize a satisfactory definition.

Example j. For this group of items blacken space

1. if the definition states the essential characteristics of that which is defined.
 2. if the definition provides only a limited description useful in a few cases.
 3. if the definition is negatively stated, that is, in terms of what the concept is not.
 4. if the definition is expressed in uncommon and non-descriptive language.
 5. if the definition doubles back to repeat itself.
- (5) 107. An anesthetic is a sleep-producing drug.
- (3) 108. An invertebrate is an animal without a backbone.

The ability to recognize the information that is pertinent to the approach of a problem may be observed by such an item as:

Example k. For this group of items refer to the problem and blacken space

1. if the statement is directly related to the solution of the problem and true.
2. if the statement is unrelated to the solution of the problem but true.
3. if the statement is false.

Problem: A balance may be in equilibrium with a beaker of water on one of the pans but will not stay in equilibrium if a weight is submerged in the beaker even though the weight may be supported by a chain and not allowed to touch the bottom of the beaker and the water in the beaker does not overflow.

- (1) 117. Every action in one direction is accompanied by an equal action in the opposite direction.
- (3) 118. All submerged bodies displace an amount of water equal to the weight of the submerged body.

The next group of items is related to the ability to obtain information from graphic data.

Example l. For this group of items the graph shows changes in the lift and drag of an airfoil with changes in the angle of attack. Blacken space

1. if the statement is entirely supported by the data.
 2. if the statement is entirely contradicted by the data.
 3. if the statement is neither supported nor contradicted by the data.
- (2) 127. The airfoil has no lift at a zero angle of attack.
- (3) 128. Increasing the speed of an airplane will increase the lift even though the angle of attack remains the same.

A type of exercise may be built to observe a student's ability to recognize the planning or basic scheme upon which an experiment may be conducted.

Example m. This group of items presents brief references to some experiments and statements of how experiments may be planned. Blacken the appropriate space to show

which type of planning is most evident in each of the experiments.

1. To determine the one and only one circumstance that is involved every time the event occurs.
 2. To determine the one and only one circumstance that, if lacking, the event does not occur.
 3. To determine not only the one and only one circumstance involved whenever the event occurs but also the circumstance which, if absent, the event does not occur.
 4. To determine what part of a situation cannot be proved to be dependent upon known events and then assume that what is left is related to the unaccounted-for event.
 5. To determine the circumstance that, whenever it is changed, a change occurs in the event under study.
- (3) 137. Two identical mosquito-proof compartments were prepared. In one, mosquitos which had bitten yellow fever patients were placed. Non-immune men lived in both compartments. Only the men in the first compartment contracted fever.
- (1) 138. In a study of the digestion of proteins, one flask was prepared with water and a protein; a second with water, saliva, and a protein; a third with water, saliva, protein, and hydrochloric acid; a fourth with water, saliva, protein, hydrochloric acid, and pepsin; and a fifth with water, protein, hydrochloric acid, and pepsin. The protein was digested in only the fourth and fifth flasks.

Although the ability to see the limitations on a conclusion drawn from an experiment appears to be definitely related to successful procedure in the work of a scientist, it is difficult to construct items to observe a student's reflection of this ability. One attempt takes the form:

Example n. For this group of items study the experiments described in the item and blacken space

1. if the conclusion does not answer the problem prompting the experiment.
 2. if the conclusion is not in agreement with the facts of the experiment.
 3. if there are not enough facts revealed by the experiment to make the conclusion valid even though the conclusion is in agreement with biological science.
 4. if due to lack of proper controls or other poor experimental technique the observations from the experiment prompted a conclusion in disagreement with accepted biological science.
 5. if the conclusion is tentatively justified.
- (5) 147. To determine the food value of a one-ounce slice of bread, it was completely burned and the amount of heat given off very carefully measured by allowing it to be absorbed by 25 liters of water. The temperature of the water was raised 3°C. *Conclusion*—A one-ounce slice of bread completely oxidized in the body would yield 75 large calories of energy.
- (4) 148. To prove that growing plants give off moisture, a healthy plant and a dead plant were placed

under identical glass jars. The following day moisture was observed to collect on the inside of both jars. *Conclusion*—Living and dead plants give off water vapor.

Although the two preceding sample items showed quite satisfactory statistical performance in one examination other items in the same group were quite erratic. One item involving a description of a rat maze learning experiment and the conclusion—"We learn by the satisfaction of a successful trial and the dissatisfaction of an unsuccessful error" did not perform at all according to expectations. Sixty-seven per cent of the students were willing to apply the data from an experiment with rats directly to a conclusion related to human learning with only one per cent of the high group and three per cent of the low group agreeing that a conclusion regarding the learning process in man did not follow directly from an experiment performed on rats.

The ability to translate observations into generalizations is typical of the abilities that almost have to be tested for at a vicarious level. The ability to evaluate generalizations is such an approach.

Example o. For this group of items blacken the appropriate space to show which practice regarding the statement of a generalization is most apparent in the paragraph reported in the item.

1. Inaccurate use of inappropriate comparisons or metaphors that were suggested by previous experiences with other things.
 2. A desire to fashion an explanation that would support or, at least, not weaken established doctrines, customs, or beliefs.
 3. Hasty generalization before adequate facts had been observed.
 4. Using inadequate sampling, applying group results to individual cases, ignoring chance correlations, or other statistical errors.
 5. Stating concepts or principles by considering the inter-relationships between directly observable facts.
- (3) 157. They say that every animal proceeds from an egg, but here there is none. Take this veal broth, bottle it and stop it, and in a few days or weeks, according to temperature, it will abound with myriads of animals. There must then be particles of matter which are made to associate spontaneously and are endowed with life as far as the present state of our knowledge goes.
- (1) 158. The curiously figured forms of fishes, insects, and other living things found in rocks have appeared there as ornaments for the inner and secret parts of the earth just as tulips, roses, and pretty birds adorn the surface of the earth.

It is apparent that there is decreasing objectivity in these latter types of items. The point at which such items cannot be used for evaluation and must be limited in use to learning exercises is a decision for the individual instructor or examiner. This is

President Truman Appoints National Science Foundation Board

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The 24 board members of the National Science Foundation appointed by President Truman to make national policy for scientific research and education and administer government grants are representative of all sections of the nation and the broad fields of science, engineering, and industry.

Among the membership are seven university presidents, heads of two big foundations, 11 deans, department heads, or professors of colleges, and two industrial presidents. Sixteen states and the District of Columbia are represented on the board of 24. Professionally, the board includes four biologists, four chemists, four educators, two engineers, one geologist, two industrialists, one mathematician, three medical scientists, and three physicists.

The members appointed are Dr. Sophie D. Aberle, special research director, University of New Mexico; Dr. Robert P. Barnes, head of the chemistry department, Howard University; Chester I. Barnard, president, Rockefeller Foundation; Dr. Detlev W. Bronk, president, The Johns Hopkins University; Dr. Gerty Theresa Cori, professor of biological chemistry, Washington University Medical School; Dr. James Bryant Conant, president, Harvard University; Dr. John W. Davis, president, West Virginia State Col-

lege; Charles Dollard, president, Carnegie Corporation; Dr. Lee A. DuBridge, president, California Institute of Technology; Dr. Edwin B. Fred, president, University of Wisconsin; Dr. Paul M. Gross, dean of Duke University Graduate School; Dr. George D. Humphrey, president, University of Wyoming; Dr. O. W. Hyman, dean of medical school and vice-president, University of Tennessee; Dr. Robert F. Loeb, Bard professor of medical services, College of Physicians and Surgeons, Columbia University, and Dr. Donald H. McLaughlin, president of Homestake Mining Co., San Francisco, California.

Others are Dr. Frederick A. Middlebush, president, University of Missouri; Edward L. Moreland, partner, Jackson and Moreland, Boston, Massachusetts; Dr. Joseph S. Morris, head of the physics department and vice-president of Tulane University; Dr. Harold Marston Morse, professor of mathematics, Princeton University; Dr. A. A. Potter, dean of engineering, Purdue University; Dr. James A. Reyniers, director of bacteriology laboratories, Notre Dame University; Dr. Elvin C. Stakman, chief, division of plant pathology and botany, University of Minnesota; Charles Edward Wilson, president, General Electric Co., and Rev. Patrick Henry Yancey, professor of biology, Spring Hill College.

especially true of items which involve interpretative abilities. If the response may be based on the recall of specifically-taught information, its validity may be questioned even though its statistical performance will tend to run high. The final modification of the basic matching type item represents the limit to which the author has seen fit to go in attempting to observe objectively a student's performance on these more complex mental processes. Observations so acquired should be examined closely before using them for grade assigning purposes.

Example p. For this group of items study the paragraphs and blacken space

1. if the discussion represents an event as being the activities of living things.
2. if the discussion represents an event as the reward or punishment for an act.
3. if the discussion represents an event as the activity of fate.
4. if the discussion represents an event as having a mechanical cause.
5. if the discussion represents an event as accompanied by other specific events to which it is apparently related.

(2) 167. The man's beard is a secondary sex character-

istic, the function of which was probably to render the difference between man and woman evident at a distance, to indicate the sex of the wearer, and to give the male an appearance of power and dignity.

- (3) 168. We human beings deserve no credit for dactyloscopy, since we did not invent it, but only discovered it. We can therefore truly say that it is a real miracle, both of nature and of mathematics.

The student performance sought through many of the items presented in this paper could, probably, be elicited by essay examinations but the statistical study of such performance would be very difficult. It is the author's thesis that if adequate study be given to the statistical performance of trial runs of experimental items it is possible to construct examination items that will reliably measure many levels of performance ordinarily held to be beyond the limits of a short-answer or scoring-sheet type examination. Once the statistical performance of such items has been established at a satisfactory level this will tend to increase the range of factors which can be given objective treatment in educational research.

Eyes and Ears

—for Elementary Science

By HELENA CRAKE

Elementary Teacher, Queen Mary School, Vancouver, B. C., Canada

AUDIO-VISUAL TEACHING AIDS do help to pave the royal road to learning, providing the pathway along which the students travel is paved with careful thought and preparation on the subject by the teacher.

In order that the most efficient use be made of all types of audio-visual aids as a lesson aid, the classroom teacher must first instill in the minds of the students that the film or slide or picture is merely assisting the textbook, and should not be referred to as a "show," but as audio-visual teaching materials. And no visual aid takes the place of the teacher, no matter how valuable one rates the visual aids—it is but one more tool in the teacher's hand.

Visual memory is added to the spoken word from the science lessons taught in elementary schools, through high school and even at the university level. Students grasp more quickly and remember facts longer if they are demonstrated in pictorial form. All visual aids are a marvelous help, especially to follow up a lesson already taught through traditional methods.

A lesson we covered in science was the study of birds in our vicinity. Several lessons were provided in the classroom on these beautiful and useful creatures who serve us well through the pleasure they give us, and by destroying insect pests and weed seeds. The students watched and studied the birds around school and near their homes, and discussions in the classroom proved the interest in the subject and the knowledge gained. Their nests were discussed, the different habits of each kind of bird were compared, and drawings of nests and other details the pupils had observed were of great value.

Probably the most interesting of the birds were the robins, as all were keenly interested in reporting the first to be seen when they returned in the spring. They studied the robin family from the day the first greenish-blue egg was laid until the last fledgling left the nest about four weeks later. A

robin's nest was brought, and a study was made of the structure. Before a film was shown, each student had learned that the young birds, whether robin, goldfinch, meadowlark, swallow, cardinal, or blue jay, are all fed alike, and all open their mouths whenever the nest is touched.

After this study of two or three lessons, the film *How Birds Feed Their Young* was shown. It is a silent film, in color, and suitable for all lower grades. It portrays very effectively the feeding habits of many of our British Columbia birds, showing how the mother and father birds feed their young. The birds which are familiar to our children in this district, such as the humming bird, quail, bluebird, and grouse, are shown, as well as some not so familiar, as the snakebird.

The lesson following the film brought many interesting questions, and more enthusiasm than was at first anticipated. What is the smallest bird?—the humming bird. The largest bird?—the ostrich. How far do birds fly? This was a difficult question to answer, but the humming bird has been known to fly 600 miles, so that answer satisfied the students. Many other questions and answers were given, and then each pupil wrote a short article on one of the following questions.

1. How busy do baby birds keep their parents?
2. What birds shown in the film are not fed by their parents?

This article clearly indicates Miss Crake's particular interest in the use of audio-visual materials as aids to making science more interesting and attractive to her pupils. She is an elementary teacher in the Queen Mary School in Vancouver, B. C., Canada. In addition to her teaching duties, Miss Crake has charge of the audio-visual program for her school.

The accompanying picture was taken in the Queen Mary School by Mr. Gordon Kilpatrick, director of audio-visual aids for the Vancouver school system.



3. What birds in the picture have you seen before?
4. Why do you imagine the snakebird is called by that name?
5. What is the main food of the baby birds?
6. How do you think most of these pictures were taken?
7. Why is a color film best in taking pictures of birds?

In the study of the habitat of amphibians in science, the illustrated material available is the Encyclopedia Britannica film entitled, *The Snapping Turtle*. It provides a link-up with the life of toads, frogs, and other animals in the water, on land, or at home. The film shows, as no verbal lesson could, how the turtle uses its claws and jaws for obtaining food, how it lays, buries, and hatches eggs, and how it hibernates during the cold months of the year. It presents the life story of this interesting reptile in its natural habitat. These unusual photographic studies in this particular film permit observations of the turtle's features, its encounters with other animal life, the laying and protecting of its eggs, the hatching and developing, and many other characteristics.

There are dozens of other slides, films, and filmstrips available to help provide more effective teaching and learning situations. They cover a variety of subjects such as steel, coal, the atmosphere, power, petroleum, plants, animals, and the human body.

I recall an incident discussed recently by one of our outstanding university professors. He was speaking about his first trip to the British Isles.

One day he and a fellow professor were walking in the Downs. They had taken their lunch with them, and, after eating it, they rested in a quiet spot and chatted. All of a sudden the visiting professor was lost in thought. He saw and heard something he had never seen or heard before. It came nearer, and the professor asked his friend what it was. The friend said, "Have you been teaching literature in Canada?" "Yes," was the reply. "And have you ever taught Shelley's *To a Skylark*?"

How much more effective his lesson would have been if his students had been able to see a film on the skylark. The professor told how very effectively he thought he had taught the lyric where Shelley shows characteristic passion and profusion of imagery in his methodical plan of three equal divisions of his subject, and yet he had no conception of the bird he was discussing in the poem.

Higher still and higher
From the earth thou springest
Like a cloud of fire;
The blue deep thou wingest,
And singing thou dost soar, and soaring ever singest.

In the golden lightning
Of the sunken sun,
O'er which clouds are brightening,
Thou dost float and run;
Like an unbodied joy whose race is just begun.

Teach me half the gladness
That thy brain must know,
Such harmonious madness
From my lips would flow;
The world should listen then, as I am listening now.

Narration In Films for Science

By **GEORGE G. MALLINSON**

Professor of Psychology and Education
Western Michigan College of Education, Kalamazoo

A SEARCH through audio-visual literature reveals that there is abundant evidence of the value for using films in the teaching of science. Many studies have been undertaken to compile lists of films, to evaluate them with respect to their accuracy, and to determine the most effective means for using them. However, most of these studies deal only with the visual characteristics of the films.

It would seem reasonable, therefore, to state that if films are considered to be *audio-visual* aids, attention may well be directed toward evaluating their *audio* characteristics. Hence, it is the purpose of this study to evaluate the narrations in certain films designed for science courses at the junior-high-school level with respect to their vocabulary levels.

Numerous studies have been made of the instructional values of sound and silent films. Many of us have been quite concerned that the films we use *show* clearly, simply, and accurately the subject matter intended to help fortify various learnings. Dr. Mallinson adds another dimension, raising the question of the sound film's index of listening difficulty. The findings from his investigation carry implications for both users and producers of educational sound motion pictures, and probably for the audio portions of other multisensory aids.

Following four years experience as an elementary and high school teacher, Dr. Mallinson completed his doctorate at Iowa State Teachers College and served one year on the training staff of this institution. He has been at Western Michigan College of Education for three years.

(By the way, it appears that this is a "Michigan" issue of *The Science Teacher*. Purely coincidental, we assure you. Good science education goes on elsewhere, too, as we'll tell you in the next issue when other states will be heard from—notably Texas and Missouri.)

Five of the major publishers of sound films for science were asked to submit the titles of two of their sound films that they considered to be of value for junior-high-school science. Further, the films so named were to meet these qualifications:

1. One was to deal with a topic in the area of biological science and the other, physical science.
2. The two films were to be selected from among those that the publisher rated "best" in his library.

All of the publishers responded in the manner requested, and during the month of April, 1950, the ten films so named were scheduled for projection. As they were projected, copies of the entire narrations of all the ten films were prepared by a secretary. The next step was to determine the most effective means for evaluating the narrations with respect to their difficulties of vocabulary level. A search through the literature failed to reveal any way for evaluating *audio* material, similar to the manner in which the Flesch formula¹ is used for evaluating written material. It was, therefore, decided to evaluate the words in the narrations using both the Thorndike² and Buckingham-Dolch word lists as they appear in the publication *A Combined Word List*.³

All the words were then compared with the word lists to determine the grade levels of difficulty assigned to them. Those whose average level of

¹ Flesch, Rudolf. *The Art of Plain Talk*. New York. Harper and Brothers. 1946. P. 205.

² *A Combined Word List* does not designate words in the Thorndike list according to grade level of difficulty. However, the grade levels of the words in Thorndike's list were computed by extrapolation of the curve in *The Vocabulary of School Pupils: Contributions to Education, Volume 1* (J. Carleton Bell, ed.), Yonkers-on-Hudson. World Book Co. 1924. Pp. 69-76 (Data provided by E. L. Thorndike).

³ Buckingham, B. R. and Dolch, E. W. *A Combined Word List: Contributions to Education*. Boston. Ginn and Company. 1936. Pp. 21-185.

difficulty according to the Thorndike and Buckingham-Dolch lists were seventh grade or below were considered to be suitable for use in the films. Those whose levels were higher were again examined. If a word was described or defined in the narration or was clarified by the visual material, it was also considered suitable for use. A list was then made of the words whose average grade levels of difficulty were higher than seventh and not described or clarified as indicated.

The table at the right lists these words together with their grade levels of difficulty computed by averaging the ratings from the Thorndike and Buckingham-Dolch lists.

Conclusions

In so far as the techniques employed in this study may be defensible, the following conclusions seem justified:

1. A total of 87 words in the ten films had an average level of difficulty above seventh grade. Hence, it is doubtful whether the younger students in junior high school, or the students of low intelligence, would have understood them. It is equally unlikely that the sections of the film in which the words appeared would have been understood to the optimal extent.

2. The number of difficult words in the different films varied. One film contained six, while another contained 29.

3. Many of the words which were found difficult could have been replaced by easier synonyms (i.e., *slows* for *retards*).

4. In many cases the difficult words were found in sentences which would have made them even more difficult to understand (i.e., *constrict*, *caliber*. "For by virtue of the muscles that encircle the walls small arteries are able to *constrict* or to dilate to increase or decrease their internal *caliber*.")

5. The lack of effectiveness of some films for teaching science may be attributed partly to the levels of vocabulary difficulty of some of the words in the narrations.

6. Some films designed for use in the junior high school may be used more effectively, in so far as vocabulary difficulty is concerned, in the upper grades of the secondary school, or even higher.

7. Film publishers need pay greater attention to the narrations in the films they publish to assure that the words are suitable for the grades for which they are recommended for use.

TABLE I
Difficult Words in Films for Science for the
Junior-High-School Level

Word	Average Grade Level of Difficulty	Word	Average Grade Level of Difficulty
abscess	10.5	inversely	13.0
aeronautical	10.5	invigorating	8.5
algae	9.0		
anesthetize	8.0	liberate	7.5
antibodies	9.0	lymphatic	11.0
aorta	12.0		
appendicitis	8.5	mechanisms	8.0
arterial	14.0	milligram	8.5
auricular	15.0	miniature	8.0
auricle	11.0	mucous	9.0
bacillus	9.0	nasal	8.0
caliber	10.5	orbits	7.5
capillaries	8.0		
centrifugal	9.5	parasol	13.0
cervical	14.0	penetrate	8.5
cilia	9.0	phagocytic	12.0
ciliary	9.0	propelled	8.0
clarity	16.0	propellor	14.0
collide	10.5	proportional	13.0
composite	8.5	protective	8.5
constrict	14.0	pulmonary	9.0
contractile	10.0	pus-filled	13.0
defensive	8.0	radioactivity	10.0
destructive	7.5	resistance	7.5
devouring	9.5	retard	9.0
dilation	15.0	rhythm	8.0
disc	7.5		
disintegrate	9.0	secretes	7.5
		sedate	9.0
economic	8.0	serum	9.0
ejection	9.0	shunted	13.0
engulfed	11.0	skeletal	14.0
excretion	8.5	spontaneously	8.0
experimentation	14.0	stimulation	10.0
		sufficiently	10.0
filtering	8.0	swirling	9.0
forethought	10.0	synthesis	9.0
formulated	9.0		
		unstable	8.5
gastric	8.0		
gauntlet	8.5	vaccines	13.0
gravitational	9.0	vacuole	11.0
		vacuum	7.5
horsepower	8.0	velocity	8.0
		venous	10.0
inefficient	10.5	ventricles	9.0
infectious	8.0	virtually	9.0
inflammation	9.0	viscera	14.0
injection	9.0	visualize	11.5

A Plea for Inductive Teaching

By FRANCIS D. CURTIS

Professor of Education, University of Michigan, Ann Arbor

IN THEIR REQUIRED courses in psychology prospective teachers of science are taught the nature and importance of both the inductive and the deductive method of instruction. Yet, later, when these young teachers begin their careers, they follow the practices of an overwhelming majority of veteran high-school teachers, and probably also of college teachers of "lower-bracket" science courses, in practically, if not completely, omitting the inductive method.

In inductive teaching the pupil starts with some problem, the answer to which he does not already know. He then assembles, by observation or experiment, or both, evidence from which he can arrive at a tentative answer to the problem. In other words, as stated by the Forty-sixth Yearbook Committee, N.S.S.E.,¹ "By inductive teaching is meant progressing from the particular to the general, or more specifically, from facts to concepts and principles."

In deductive teaching the pupil starts with the solution of a problem, presented to him usually in the form of a stated concept or principle accompanied by applications and illustrations. He then makes observations or performs experiments for the purpose of verifying what he has already been told is true. Thus he proceeds from the general to the specific.

The two methods are mutually complementary. The inductive method is the one by which scientific knowledge has grown from its earliest beginnings; the deductive method is that by which civilization has been advanced through the applications of the facts, concepts, and principles discovered by employing the inductive method. Both methods are essential and uniquely contributory to human progress. Therefore, it seems obvious and unquestionable that every science course must provide boys and girls with functional training in both these methods.

Where the deductive method is supreme, as it is in the typical high-school course, the assignments of materials to be studied in the textbook or other sources precede the laboratory work. The

inductive method is by-passed. Where the inductive method has its merited and logical place, as it has in a small but increasing number of high schools, these procedures are reversed. The laboratory work comes first and the study assignments follow it. The deductive method is then introduced as the final step, in applying the facts or principles which the pupils have discovered inductively.

The characteristic difference in the function of laboratory work under the two methods can be interpreted from the stated "purposes" of experiments. Typical purposes of experiments to be performed deductively might be stated thus: "To Study Plant and Animal Cells," or merely, "Plant and Animal Cells," "To Study the Properties of Nitrous Oxide," "To Test Boyle's Law." The purposes of the corresponding experiments to be performed inductively, might be stated thus: "How many ways can you discover in which the single-celled animals and plants, in the cultures we have made, are alike, and how many ways can you discover in which they differ among themselves?" "Is nitrous oxide a solid, a liquid, or a gas?" "Has it a definite color?" "Does it change in any way

DR. CURTIS, one of the "deans" of science education in America, had an article in last April's issue of *The Science Teacher*: "Individualized Laboratory Work Must Be Retained." We received a couple of letters of disagreement with such a bold statement, the counter claim being that much of our present "laboratory" work isn't worth being retained. Well, it seems to us that Dr. Curtis gives the answer in this article—he is not willing to accept just any kind of laboratory work. It must be laboratory work that is purposeful and designed to fit into a planned sequence of instruction. Moreover, he sees the inductive or developmental approach as just about the ideal setting for truly experimental laboratory work.

In addition to being largely responsible for the training of hundreds of science teachers during his 27 years at the University of Michigan, Dr. Curtis is widely known for his many researches in science education, his three Digests of Investigations in the Teaching of Science, his contributions to the 31st and the 46th Yearbooks of the National Society for the Study of Education, and as an author of high school science textbooks.

¹ *Science Education in American Schools*. Forty-sixth Yearbook, N.S.S.E. University of Chicago Press, 1947, P. 49.

when mixed with air?" "How does the pressure of a confined gas change, if at all, when you increase or diminish its volume, but do not heat it or cool it?"

Thus, with the inductive method, the laboratory work presents a problem and a challenge which the deductive method rarely provides. If a pupil does not know the answer to a question, his curiosity is aroused. He is stimulated to try to find the answer. If he already knows the answer, there is usually little to be gained from his merely verifying it, even if the facilities available to him will make possible his doing so. It will usually be more profitable for him to work on another problem the answer to which he does not know, or upon some aspect of the intended problem which is not yet known to him. This latter suggestion offers about the only effective way to combat the difficulty encountered with increasing frequency by teachers of biology, chemistry, and physics, and often, also, of general science, whose pupils have had the keen edge of novelty and anticipation dulled by earlier experiences with science, and who, therefore, greet proposed activities in later courses with the chilling "We know all that already," or "We did that in grade school."

Students Enjoy Verifying Experiments

There is no doubt that boys and girls in general like to verify experiments. They enjoy the manipulating even when it is perfunctory. But, when they know in advance what results to expect, they commonly engage in one or more of several unscientific practices: They report that they have observed what they believe that they are expected to observe; they change their data to make their results "come out right"; they even sometimes "write up" the report of an experiment without having performed it at all. It is not uncommon for pupils, while verifying "experiments," to ask their teacher, "Shall I tell what happens or what ought to happen?" and, preposterous as it sounds, teachers in such cases have been heard to reply, "Put down what ought to happen."

Recently, following a presentation of the values of the inductive method during a conference on laboratory teaching, a teacher who confessed that he used the deductive method exclusively objected, "Wouldn't it be a farce to turn a beginning student loose on an experiment which he did not know how to perform and to let him wander down a blind alley *ad lib*, with no notion of where he was going or how to get there?"

Of course it would. But no teacher who understands how to use the inductive method would

advocate or countenance such a senseless procedure. In at least the beginning stages of his learning to use the inductive method, the pupil needs just as careful and complete directions as those customarily furnished with the corresponding experiments and observations, when these are to be carried out deductively. It would of course be ineffective, time-wasting, confusing, and often dangerous to permit an untrained pupil to do laboratory work without careful guidance. A fundamental difference between the two methods, therefore, is not the presence or the lack of directions, but is the way in which the directions function. With the deductive method specified procedures lead the pupil to results which he expects; with the inductive method, the corresponding directions lead him to discover facts or principles previously unknown to him.

Opportunity Better for Teaching Scientific Methods

It seems unquestionable, then, that the inductive method provides better opportunities for teaching the elements of scientific method than does the deductive. With the former the pupil is encouraged to make hypotheses with respect to the probable outcomes of his investigations. His interest is stimulated by the need to check his hypotheses against the outcomes. He is easily convinced of the necessity for identifying and isolating experimental factors and of the value of introducing controls and of making check experiments. Since he does not know what are the accepted results, he records his findings with scientific honesty. As he becomes more and more skillful in the use of the inductive method, he can be given increasing opportunities to grow in his ability to use the scientific method, by allowing him more freedom in planning the steps by which to solve his problems.

Correct Procedure Depends on Teacher

In discussions of the two methods the question is usually asked, "What is to prevent the boys and girls from looking up the answer in advance and then verifying it by observation and experiment, just as they would with the deductive method?" Probably they cannot be completely prevented from doing this. But whether most of the class thus "fortify" themselves, or only a few do so, depends on what the teacher does. Before the latter can be effective in discouraging the pupils from thus "putting the cart before the horse," he must first free himself from the idea that pupils can reasonably be expected to obtain the "right" results

from a considerable part of their laboratory work. He must accept the fact that if the experimenting and observing are done in accordance with the ideals and procedures of true scientific method, then the pupils often will not, and in many cases cannot possibly, secure the "standard" results; he must realize the absurdity of expecting boys and girls in a beginner's course to duplicate the cumulative results achieved by the great scientists during many centuries.

When pupils take the trouble to find out the accepted outcomes of an experiment in advance of its performance, they usually do so because they are afraid not to. They fear that if they later report any results but the accepted ones they will "get a low mark" or will be penalized in some other way. Regrettably, in many cases, their apprehensions are justified.

No Bonuses for "Right" Answers

The teacher can discourage and almost completely eliminate the practice of looking up the "right" answer before the experimenting is done by convincing the boys and girls that they will gain nothing by so doing and will suffer no handicaps by not. No matter how conscientiously eager the teacher may be for the class to learn the correct answer, he must resist the temptation to reward or encourage, with an approving smile or a commendatory word, a pupil who "contributes" the answer before the laboratory work has been done. Furthermore, the teacher must not penalize the pupil for not getting the accepted results when there is a reasonable excuse for his failure; but he should do so whenever the boy or girl reports findings which the method and experimental facilities render impossible. After the teacher has taught through a course a time or so, he knows approximately what results his pupils may reasonably be expected to secure with the apparatus and equipment at their disposal.

A skillful teacher influenced her class to postpone looking up the results of an experiment before performing it by introducing it in this way, "Let us suppose that nobody has ever studied what we are now going to study and that the world is waiting for what we shall be able to find out. Of course, after we finish, we shall check our results with those which we know that scientists *have* determined, but let's see what results we can actually get with what we have to work with."

An objection to the use of the inductive method sometimes voiced is that "it takes too much time,"

and that, as a result, relatively little laboratory work can be completed with it. This objection suggests the conviction that in every course there is a certain number of experiments which must, or at least should, be performed. This not uncommon idea reflects the influence of the Harvard List of experiments which began to exert its powerful control over laboratory work in physics nearly three quarters of a century ago.

Reflects Emphases on Teaching Facts

It also reflects the present preponderant emphasis upon teaching factual information as a major objective, if not *the* major objective, of science courses at the elementary and secondary levels. If, however, we accept modern authoritative opinion, based upon the findings of extensive research,² that, with conspicuous exceptions, few facts are valuable in themselves, that, if learned, their retention is astonishingly and discouragingly ephemeral, and that they are chiefly useful as the means by which understandings of concepts and principles can be established, then the *number* of experiments performed becomes relatively unimportant. The effective *training* needed for realizing the major objects of the science courses can be effectively achieved with relatively few experiments provided that these are performed in accordance with acceptable scientific method. Hence condemnation of the inductive method on the basis of quantity of experimentation achieved with it, is not justified.

Inductive Method Wastes No Time

Furthermore, teachers who employ the inductive method deny that it is expensive of laboratory time. They insist that it does not reduce the amount of laboratory work that can be done. They confidently assert that after the first few weeks, by which time the teacher has achieved proficiency in teaching the method and the pupils have become reasonably skillful in applying it, a class will "pick up speed"; and that by the end of the course its members will have completed as many experiments as would a comparable class using only the deductive method.

The inductive method makes the laboratory part of a science course a fascinating adventure. The teacher who gives it a thorough trial will never discard it. Instead, he will make it a major implement in all his science teaching.

² Ibid., Chapter III.

A Jet Model That Works

By E. JOE ALBERTSON, JR.

General Science Instructor
Roslyn High School, Roslyn, New York

FOR 67 CENTS worth of common household materials a small working-model jet engine can be built which will effectively demonstrate the basic principles that underlie jet and rocket propulsion. Applicable to both general science and physics classes, this easy-to-build, simple-to-operate model is patterned after Hero's famous steam-jet engine of 2000 years ago.

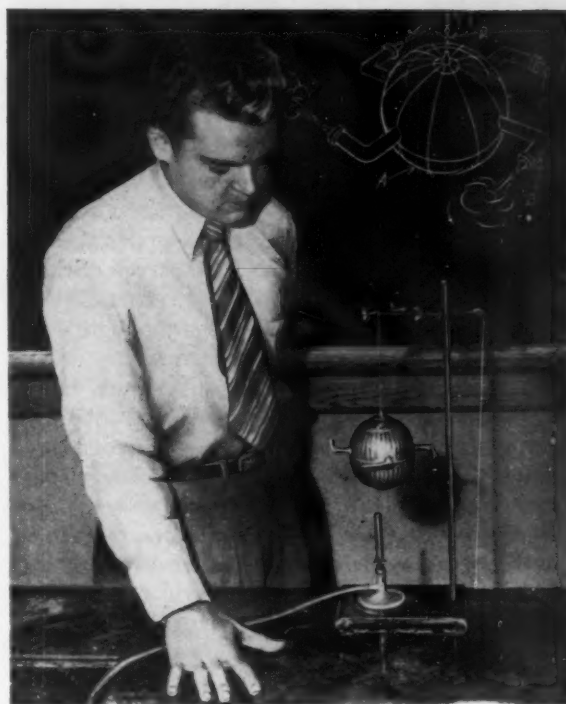
Used as either a student project or teacher demonstration, it supplies an unique and fascinating approach to the study of Newton's Law of Reaction, and to classroom discussions of present-day achievements in jet-propelled aircraft, rocket development, and the intriguing prospect of interplanetary travel. This model will also lend itself nicely to a consideration of the history of jet development, which, contrary to popular belief, dates back to early times and was often an interesting blend of remarkable ingenuity and humorous efforts.

A simple, copper tank float provides the body for the jet engine. Copper tubing, one-quarter inch in diameter, cut into four equal lengths, approximately three inches long, should be bent in the middle, at right angles, to form the four separate nozzles for the engine. Attach these to the body in the following manner:

Punch four holes around the mid-section of the float at equal distances. These may then be enlarged to size by filing. The diameter should be just large enough to accommodate the copper tubing in a snug fit. Insert each nozzle and solder firmly in place, being careful to make a water-tight seal.

For nozzle heads, salvage four caps from the spouts of empty oil cans of the "3-in-1" variety. It will be found that these caps fit snugly into the opening of the $\frac{1}{4}$ -inch nozzles. The soft metallic nature of the caps makes it easy to punch a tiny hole through the end with a straight pin. The nozzle heads may then be inserted and removed from the nozzles at will. The snug fit makes soldering unnecessary and adds greatly to ease of construction and operation. The tiny aperture develops a high gas pressure which will drive the jet at great speed.

The model is now complete except for the attachment of a swivel hook to allow the engine to



A. TANK FLOAT—body; B. COPPER TUBING—nozzle; C. LEAD CAPS—nozzle heads; D. PULL-CHAIN—swivel support.

revolve freely during operation. While many different fixtures can be used, an ordinary bronze pull-chain from a discarded lamp is quite suitable. Solder its bell-shape terminal to the top of the float. Then the engine will be free to revolve while firmly supported by the chain.

Operating the model is simple. Partially fill the float with water through an open nozzle. Then insert all the nozzle heads and apply heat to the bottom of the float.

As the water begins to boil, a fine spray of steam jetting out from each nozzle head will be noticed. Slowly the engine begins to rotate as exhaust-pressure builds up. Soon the model whirls at high speed, accompanied by the characteristic "trail" and sound of jetted steam.

Cost List

1 Tank float, copper	\$0.47
$\frac{1}{4}$ " Copper tubing (12-inch length)	0.15
Solder	0.05
4 Oil can caps, soft lead	0.00
Lamp pull-chain, bronze	0.00

Total Cost \$0.67

Classroom Ideas and Demonstrations

Astronomy

Making Slides

By HAROLD HAINFELD, Roosevelt School,
Union City, New Jersey.

Producing a visual aid suitable for a class in astronomy is a project now being undertaken by the eighth-grade students of Roosevelt School. All the equipment that is needed is a 35-mm. camera, a small tripod, one or two floodlights, and a piece of etched glass or waxed paper.

Those familiar with photography know that a black-and-white negative is the opposite of the positive print. White, when photographed, will be black on the negative, and black will be white. By photographing drawings of constellations drawn with black India ink on 11 × 14-inch white drawing paper, the negative will be black like the night sky, and the India ink drawings will be white.

The procedure for taking pictures of the star constellation drawings is as follows.

1. Mount the camera on the tripod and set the focus for the shortest distance—2½ or 3 feet on most 35-mm. cameras.
2. Set the camera for time exposure and press the shutter button. This will open the lens. Turn on the floodlights.
3. Open the rear of the camera and hold a piece of etched glass or waxed paper there. This will enable you to see the area to be photographed.
4. Place a drawing in this area on the wall or a box. This will enable you to check for proper focus. The drawing will, of course, appear up-side-down through the etched glass.
5. Lock the tripod in place. Make sure it does not move.
6. Trip the shutter to close the lens. Load the film into the camera.

All that is then necessary is to photograph the series of constellation drawings. It may be advisable to take and record a series of shots at different exposures and shutter speeds. Our experience has been that using Super-XX film with an exposure of f.8 at 1/100 sec. or f.11 at 1/50 sec. gives the best results. For illumination we use 100-watt lamps in reflectors placed 4 ft. from the drawings. Drawings in India ink appear more realistically in the negatives than drawings made with crayon, pencil, or chalk.

After the film was processed, the students eagerly bound the negatives in 2 × 2-inch slide binders and covered them with thin glass wafers to protect the film. When projected in the darkened classroom or visual aids room, a realistic sky picture appeared on the screen. The students enjoyed the slide making. Added interest was shown in astronomy and photography. Plans now call for similar drawings and slides to be made of the solar system, phases of the moon, and eclipses of the sun and moon.

Not only did the slide-making project enable the students to "see the stars" during school hours, but their efforts contributed a valuable addition to the school's visual aids library.

Physics

Archimedes' Principle

By RALPH W. LEFLER, Purdue University,
Lafayette, Indiana.

How did Archimedes determine whether or not the crown was pure gold? This is a matter of history. How would *you* discover whether or not a "crown" is of pure "gold"?

In the above comparison we have a good discovery-type problem which may grow naturally out of class discussion on Archimedes' principle and contribute to departure from the "cookbook" type of laboratory exercise.

Archimedes presumably had samples of pure gold and pure silver. He also held the crown which was suspected to have been gold adulterated with silver.

You can provide a block of pure paraffin and a block of pure aluminum. You can also prepare a "crown" of paraffin which contains a block of aluminum, well imbedded so as not to be visible or obvious.

Given this "crown" and the two pure samples, the student is confronted with finding whether or not the "crown" has been adulterated; and if so, what volume and weight of aluminum has been embedded in it.

Challenge the student to solve this problem without outlining the procedure for him as our manuals so often do.

(What are your suggestions for discovery-type laboratory problems? Editor.)

Elementary Science

Cages for Small Mammals

By **DWIGHT E. SOLLBERGER**, Indiana State Teachers College, Indiana, Pennsylvania.

Materials needed for making a cage for rearing small mammals in the classroom include: (1) hardware cloth— $\frac{1}{4}$ -inch mesh, 12×47 inches; (2) one box of brass paper fasteners; (3) two cookie pans approximately 10×14 inches (the size of these determines the size of the cage and the length of the hardware cloth as given in [1]); (4) an 8-penny nail or punch to use to put holes in the cookie pans; (5) a pair of tin shears, pliers, ruler, and hammer; and (6) an empty wooden chalk box with a lid.

The procedure for making the cage is as follows.

1. Bend the hardware cloth into a rectangle of the same length and width as the bottom surface of the cookie tin. Allow 3 inches to overlap.

2. Fasten the hardware cloth with the paper fasteners so that it will hold this rectangular shape.

3. Punch two holes in each side of the cookie pan that is to be used for the bottom of the cage.

4. Fasten the hardware cloth to the cookie pan with the paper fasteners.

5. Make a hole in the narrow end of the chalk box suitable for the animal to be kept in the cage and place the box in the cage.

6. Use the second cookie pan for the top of the cage.

From this activity students gain information concerning the names of tools and materials used, as well as the needs of small animals. They acquire skill in using tin shears and pliers and in measuring. The end result is a stimulated interest in animals and an increased desire to make things.

Biology

Persistence of Vision

By **MORTON L. NEWMAN**, Williamsburgh Vocational High School, New York City.

Teaching the concept of persistence of vision and its application to moving pictures may be facilitated by the following direct visual demonstrations.

1. Project a flashlight beam through a camera from the open back. Support a piece of frosted glass in front of the camera. After warning the class to observe carefully the

Army's Physical Therapy Course Now Open

The 12-months' physical therapy training course conducted by the Army Medical Service will now be offered semiannually. During 1951 classes will start in March and September.

Young women between the ages of 21 and 26 who have a bachelor's degree with major emphasis in physical education or the biological sciences are eligible for this training. Consideration also will be given to applicants with majors in other fields who have satisfactorily completed a sufficient number of hours in the fields of biological science, physical science, and psychology.

Selected applicants will be commissioned in the grades of Second Lieutenant in the Women's Medical Specialist Corps Reserve of the U. S. Army or U. S. Air Force, depending on their choice of service, for the purpose of taking this training.

Application forms and additional information may be obtained from the Office of The Surgeon General, Department of the Army, or the Office of The Surgeon General of the Air Force, Washington 25, D. C.

flashes of light on the frosted glass, snap the shutter at different speeds, say $1/25$, $1/50$, $1/100$, and $1/200$ sec.

Ask the class which flash seemed quickest. Don't be surprised at the differences of opinion. Repeat the demonstration until the class is convinced that it is virtually impossible to tell which flash was the quickest. Now tell the class the various shutter speeds used. Why couldn't they distinguish one speed from another? The explanation that "the light stays in the eye for a time" is easily elicited. (One difficulty may develop. It is usually not difficult to distinguish the shutter speeds by sound. However, this can be covered up if the teacher makes some sounds of his own at the appropriate moment.)

2. To demonstrate the principle of the moving picture, use a variable speed projector without a film. First run it at normal speed so that the class may observe the steady light on the wall or screen. Then slow down the projector until the flicker is apparent, and finally stop it momentarily, using the clutch, while the shutter is closed and the screen is dark. Release the clutch and increase the speed once again.

If the screen is actually dark part of the time, why does the light seem steady to the eye? When this demonstration follows immediately on the first one described above, very few pupils miss the point.

Getting the Most From—

Business-Sponsored Pamphlets

By GORDON F. VARS

Teacher of Science and Core, Bel Air High School
Bel Air, Maryland

IT SEEMS probable that many business-sponsored pamphlets, such as those distributed by the NSTA packet service, are being used at less than full potential because teachers lack an efficient way to organize them. No matter how worthwhile a pamphlet may be, it is actually valueless unless it is readily available when needed. This means that not only must a particular title be easily found, but also that its existence suggests itself to the teacher at the time it can best be used.

No busy science teacher can be expected to keep in mind the great many titles and subjects now available, so it becomes necessary to devise some kind of written reminder. Any such system must be economical of the teacher's time and simple enough so that students can help run it. It must correlate all materials concerned with the same general subject and should make sure that all the potentialities of any one piece of material are utilized.

One system the author has found quite useful involves "key sheets" on which are listed the titles of all pamphlets relating to a certain subject. For example, a general science teacher may want to be able to find quickly all his pamphlets on aviation, electricity, heat, history of science, light, weather, or other units commonly studied in this course. With such a key the teacher knows at a glance what pamphlets he has that can be used with any unit of study he is undertaking. He also can be sure he has not overlooked any materials he may have filed away and already forgotten.

Such a list also makes it possible to exploit fully all the possibilities of any one piece of material. For example, the duPont pamphlet, *Salt and the Chemist*, included in one of the NSTA packets, might be useful in many different ways. The first few pages, devoted to the historical background of the salt, might well be used in a study of science history; hence the title of this pamphlet would be placed on the key list entitled *History of Science*. To make sure that the pamphlet was not overlooked

In this article, Gordon Vars suggests a method for organizing and filing business-sponsored pamphlets in order to facilitate their most efficient use. Jim Davis in his article (facing page) suggests a novel technique designed to encourage thoughtful reading by students. A list of *Do You Know* questions serves as a self-test after the first browsing and as a guide to re-reading of the pamphlet materials. The facts and ideas in Davis' article were gleaned from *Steelways*, published bi-monthly by the American Iron and Steel Institute.

Both of these "how-to-do-it's" should be helpful to all science teachers who make use of business-sponsored teaching aids. If not usable in your situation in the exact forms presented by the authors, let us have your suggestions for modifications or alternative techniques. Other teachers would like to hear from you.

in any study of the mineral resources of the nation, the title would be listed on the *Minerals* key list. Likewise, the material on page nine might warrant a listing on the sheet marked *Electrolysis*.

Some general science teachers may wish to have a list correlating all pamphlets useful for the study of *Chemistry* on a simple level, and many will wish to have a list of all descriptions of *Industrial Processes*. A chemistry teacher using this booklet would go further and list it under both *Sodium* and *Chlorine* for use in more thorough study of these elements in advanced courses.

While it might seem unnecessary to list this one pamphlet in so many different places, experience has shown that placing it in one single category, such as *Chemistry* or *Salt*, severely limits its usefulness. When a pamphlet is "tied in" with as many subjects as possible, it is more likely to be used. In actual practice the time spent jotting down the title on several key sheets is far less than that which would be spent in search of the pamphlet after time has blurred the memory and confused it with other additions to the collection.

With all titles listed on appropriate key sheets, the problem of storage is much simplified. Ordinary alphabetical arrangement by title, omitting initial *a's*, *the's*, etc., is now possible, because subject correlation is done by the keys. Lettering the first few words of the title along the fold line makes it

Do You Know—?

By JAMES B. DAVIS

Teacher of Physics, Lower Merion Senior High School
Ardmore, Pennsylvania

1. How many sparks does a spark plug make when a car is going 40 miles an hour?
 2. What percentage of the metal in so-called "tin cans" is tin?
 3. How many tons of air are used for every ton of pig iron produced?
 4. Under what conditions, if any, is it safe to keep canned food in the opened can it comes in?
 5. A steel ball, dotted with paint and spinning in a centrifuge at 1800 miles an hour, tells Navy engineers how well paint will stick on new jet aircraft. The ball reaches a speed of 2,400,000 revolutions in the test. When power is cut off, how long will the ball travel around before coming to a dead stop?
 6. What rock in the Blue Ridge Mountains of Virginia, used in making silicon, chrome, and tungsten alloys, defies steel drills?
 7. The greatest height that man has ascended?
 8. Who was known as the "Dean of American Metallurgy"?
 9. How much must you pay for an American steel violin string?
 10. According to the dictionaries, a horse is "a solid hoofed perissodactyl quadruped, domesticated and used as a beast of burden and to carry a rider," but in a steel mill what is a horse?
 11. The Roman, living in the first century of the Christian, era who devised a sharp-edged file or saw that could cut into diseased teeth?
 12. How long must you lie in one position to be considered a tranquil sleeper?
 13. The name of the bacteria, now rare, that extracted iron from water and deposited it in an insoluble form?
 14. Which state produces the most steel?
 15. The name of the Biblical character who first made use of the cyclotron principle?
 16. How the hardest shove on earth can be supplied?
 17. Other meanings of the word "stadium" than the conventional grandstand idea?
 18. How many stitches a sewing machine can make when working at its fastest speed?
 19. How long it will take a crocodile to digest a quarter-inch mild steel hook?
 20. In the steel industry, what is meant by butt weld?
 21. An Egyptian Pharaoh had the goddess Isis carved in different poses on temple pillars. A fast chariot ride around the temple made Isis seem to move. Who was this first home movie-maker?
 22. What do these animal names mean to the steel industry? *Alligator, hen and chickens, glazed pig, salamander, porcupine, monkey, bug.*
 23. How magnetism helps to keep false teeth in place?
 24. How much the modern automobile would cost if made with the tools of 1910?
- (For answers see Do You Know? on page 240)

possible to keep the pamphlets in order, and students can arrange them as part of regular classroom routine. Students are more likely to browse through them if they are out on the book shelves, rather than in pamphlet boxes or the vertical file.

As a final feature, "key sheets" can be made to include suggestions for ordering new materials as they are announced in professional journals. The writer clips these reviews, glues them to library cards, and "keys" the titles in the regular way. A check mark tells which titles on the key sheet are actually on hand, while those unmarked can be ordered from the information on the library cards. In this way the teacher has on hand the necessary information for continually expanding his supply of useful teaching aids.

While this way of handling science pamphlets probably is not the complete answer, it has served the writer well as part of a general scheme of organizing all types of teaching materials.¹ It is true that any system of organization will take more time and effort than simply trusting to luck that one can find what he wants when the need arises. However, the small amount of additional effort required by this system brings great reward in enriched learning experiences for the students and satisfaction that one is getting full value from business-sponsored teaching aids.

¹ Vars, Gordon F. *Organizing Resource Materials for Creative Teaching*. Master's Thesis (unpublished). Ohio State University. 1949.



Modern Cold Storage Guards the Nation's Food Supply

By **HORACE W. WILSON**

General President, American Warehousemen's Association

SINCE THE EARLIEST recorded times food has been stored when it is plentiful. Probably the first known reference to warehousing was in the Bible when Joseph stored grain. Now foods are placed in refrigerated warehouses to preserve them not only against possible shortages but also to guarantee a constant supply of fresh, health-giving foods at all times.

Many people still think of warehouses as described by Charles Dickens: "damp, musty, old buildings inhabited by rats." The warehouses of today, and particularly the refrigerated ones, are a far cry from the warehouses of Dickens' time. Most of the buildings now in use have been built within the last 50 years, and many of them within the last 20. Generally speaking they are made of reinforced concrete, insulated with cork board with a plaster finish which is usually kept white and as nearly sanitary as possible.

The ancient Egyptians, Greeks, Romans, and others knew the cooling effect obtained by the

means of evaporation. History tells us that they hung porous clay vessels filled with water in the shade. Some of the water that passed through the walls of the vessels evaporated and, through this removal of heat by evaporation, the temperature within the vessels was reduced sufficiently to cool the remaining water, sometimes enough to form some ice. These people chilled their wines and dainty foods by means of snow brought from the mountains and sometimes by crude artificial methods. It was not until the beginning of the nineteenth century that natural ice was used to any great extent, and not until the end of that century that cold storage was used on a large scale commercially.

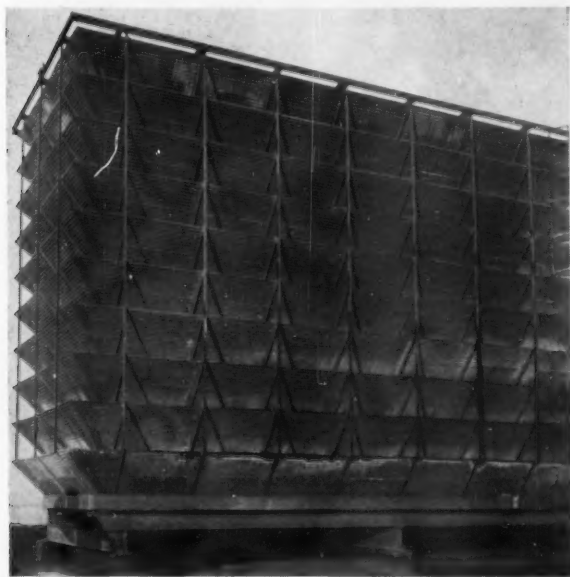
A cold storage plant must have mechanical refrigeration. Its development is another example of the "adding together" of ideas and bits of information resulting from men working over a period of many years. In 1595 Galileo made the first accurate thermometer. In 1622 Boyle dis-

covered how gases act under pressure. In 1774 Priestley added the discovery of ammonia and oxygen.

All of which gave the scientific world three important tools to work with—an instrument to measure temperatures, Boyle's Law, and a knowledge of certain gases. Later, in 1823, Faraday demonstrated that a gas can be changed into a liquid by the application of pressure. In 1834 Perkins patented an apparatus which was the forerunner of the compression machine of today, and in 1875 Dr. Carl Linde introduced the ammonia compression machine. This machine emphasized the great possibilities of ammonia for refrigeration, and even today ammonia is used in most public cold-storage warehouses.

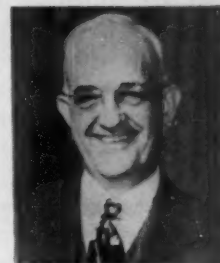
As early as 1865 fish were frozen commercially by ice from the Great Lakes. In 1870 poultry was frozen with air chilled by a mixture of ice and salt. Between 1905 and 1910 small fruits and berries were first frozen. Commercial freezing of so-called quick-frozen foods started about 1929.

Modern refrigerated warehouses are divided into a series of rooms, and frequently different rooms are reserved for certain commodities. The rooms contain pipe coils or refrigerating units that hold a gas or a liquid (generally ammonia and/or calcium chloride brine) which is constantly pumped through the coils and takes heat from the room and from the goods which are stored therein. The refrigerant is then pumped to coolers, generally in the basement of the building. In the coolers the heat is extracted from the refrigerant which is



Cooling tower on warehouse roof—a familiar sight in cities large and small.

Horace W. Wilson, author of the accompanying article, is an authority on the process of refrigerated warehousing. A graduate of Philadelphia's Girard College, he has been in the public warehousing business since 1921. President of the Quaker



Oscar & Associates
Chicago Studio

City Cold Storage Company, he directs the operation of 6,000,000 cubic feet of cold storage space. Active in the affairs of the Refrigeration Research Foundation, Mr. Wilson is also a past president of the National Association of Refrigerated Warehouses and is, at present, president of the American Warehousemen's Association.

The three pictures accompanying this article were taken at Mr. Wilson's warehouse in Philadelphia by Ludgin Photo Studio.

in turn again pumped through the rooms. This cycle continues 24 hours a day throughout the year. Warehouse machinery includes compressors, condensers, coolers, and pumps.

Different foods require different handling and different storage conditions. Some foods must be kept almost moist and others quite dry. Some foods must be kept colder than others. Also, the warehouseman always has to be careful of the intermingling of odors. Frequently it is necessary to know how and for what the foods are going to be used. For instance, potatoes—if they are stored to be used as seed—should be kept around 32° F., the lowest possible temperature without freezing them, as the colder they are kept the less chance there is for germination. When potatoes are stored to be used for general eating purposes, they have to be kept at a temperature of from 38 to 40° F., because if they are kept colder the starch in the potatoes turns to sugar, and the potato when cooked has a sweet taste which is generally considered objectionable. If they are kept warmer than 40° F., they do not keep too long, and they are likely to soften and sprout. Then they may not be desirable for home use. On the other hand, if the final use is in making potato chips or French fried potatoes, they should be stored at a temperature of from 50 to 55° F. in order to get the light brown color in the cooking; if the potatoes are kept colder, the final result may be a dark discolored product.

Foods for cold storage purposes may be divided into two main classes—fresh and frozen. The

former are stored at temperatures above 30° F. and at from 65 to 95 per cent relative humidity; frozen foods are stored at 0° F. or lower. Every room is checked at least every four hours, and records are kept showing the storage conditions.

Many foods, if not stored properly and, if not stored quickly enough, lose their vitamin content. This fact has been discovered in recent studies, and the industry is now making an effort to educate people who use fresh fruits and vegetables to buy only those that have been kept properly refrigerated. For best results produce should be kept iced from the farm to the warehouses or stores and while on display in stores.

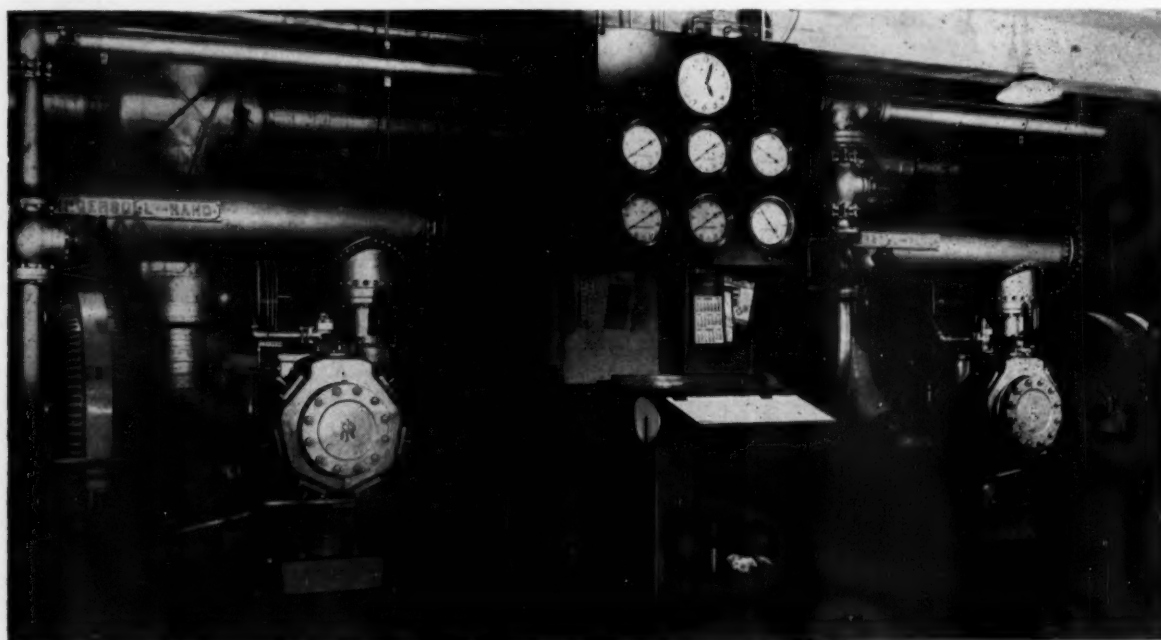
One of the latest developments is the so-called quick-frozen foods. These foods are steamed, processed, and frozen within a few hours of being taken from the field. Foods have to be frozen at different temperatures. It is now generally felt that most vegetables can be properly frozen at around 0° F. Fruits are treated with syrups or sugars and are frozen at temperatures from 0 to -15° F. Meats, fish, and poultry seem to hold up better if initially frozen at temperatures as low as -30 or -40° F., though, after any of these foods are frozen, it seems perfectly satisfactory to hold them at a temperature of 0° F. for a long period.

The public cold-storage warehouses are strictly service institutions in that they very seldom own anything they store, the foods being stored by

farmers, commission men, processors, or various storekeepers.

The original cold storage warehouses were sometimes used to preserve or to attempt to preserve food for which there was no ready sale. As a result much food that was not fit for human consumption was given to the warehouses, and, naturally, when they delivered it, it was often spoiled or in an unsatisfactory condition. This gave "cold-storage" foods a bad name. The situation is quite different today. The foods which are stored must be fresh and wholesome and are subject to city, state, and federal inspection; moreover, the warehouses are regulated by stringent laws.

The storage of foodstuffs has been carried on for a great number of years on the knowledge obtained through practice. However, in recent years an intensive study from a scientific basis has been made. Members of the cold-storage industry have set up the Refrigeration Research Foundation with headquarters in Berkeley, California. Through it work is now being conducted in a number of colleges, and it is hoped we shall learn considerably more about food values in the near future. Industry leaders are conscious of their responsibility as guardians of America's perishable food supply. Their technical achievements in the past have been great. Continued emphasis on the methods of scientific research will guarantee even greater results in the future.



Huge compressors promote the liquefaction of ammonia or other refrigerant.

A Science Teacher Looks at School Camping

By **WALTER A. THURBER**

Professor of Science, Cortland State Teachers College,
New York

MANY AREAS are showing an interest in the possibilities of a public school camping program. There is permissive legislation in some states, with schools owning their own sites and taking in pupils for day camps or overnights. There is pressure for state support for long-term summer camps. The school camping movement deserves serious consideration by all science teachers.

Due to the decreasing role of the parents in the educational picture, children today frequently come to school less educated than children of a few generations ago, particularly in regard to basic science experiences. And city children fall behind rural children, especially farm children. Once children learned through watching their parents, through imitating them, and finally through taking a share in the home duties. They learned about the production of food, about food preparation, about home fabrication of many essentials such as rugs, and they visited the relatively simple industries of the time and saw complete manufacturing processes.

Many children today are denied these fundamental experiences. Mothers carry out ever-fewer of the basic preparations. They have almost ceased the baking of yeast breads. Quick breads and cakes are more and more the results of "ready-mixes" when they are not purchased at the corner grocery. Canning, drying, and other types of food preservation have become practically extinct activities in city homes, and hams come from meat stores instead of from hogs.

Few children, except those living on farms, can learn through watching their fathers at work. There is not much basic education involved in watching father work at a highly specialized task, even if the children were welcome in one of today's business or industrial plants. And, except for the occasional parent with a constructive hobby, such as woodworking or gardening, there is little opportunity for children to participate in educational activities with their parents.

It is appalling to note the number of children who beat a track between the quiet corner with the funnies, the living room radio-television, and the neighborhood movie. Of course, there is some information in these "second-hand" educational factors, but there is also a great deal of misinforma-

tion, and there is no way for children to distinguish between the two.

We science teachers are bucking a serious problem. We cannot erect a structure of understanding without a foundation of first-hand experiences. When we try, we end with a thin, unstable shell of verbalizations. And yet we do not have time to give all the basic experiences we really need.

School camping offers refreshing possibilities. In camp children carry out many basic living activities. For the first time many of them build real fires, learning about tinder and fuels, establishing the background we science teachers need in dealing with the energy relations involved in fires. They cook, and so set a background for meaningful chemistry and nutrition. They must be concerned with sanitation. They have real experiences with the laws of mechanics, using axes and other hand tools, levers, ropes, and inclined planes, instead of dinky little pulleys and wheels and axles of the science lab.

And all the time the factors of the environment impress themselves on children in camp. Weather means something when one is out in all stages of a sequence of conditions. Astronomy, which includes movement of the sun across the sky as well as constellation recognition, is near and real. Soil, water, plants, and animals constantly affect the individual.

There seems no need to elaborate more on how camping can provide a foundation for good science teaching. Every science teacher will see the possibilities. It does seem well to call attention to the fact that social studies teachers should have an interest in school camping; in these small, primitive communities arise many of the problems of social living and the solutions on which our society is based. The camp becomes a laboratory in living.

The type of camp organization which seems best adapted for the educational purposes mentioned is that utilized by Dr. Lloyd B. Sharp in his Life Camp for underprivileged children from New York City. Of course, scout troops with good leadership have used the same organization for years.

In this type of camping the children are divided into small villages or communities. Eight children
(See CAMPING, page 241)

The Cleveland Meeting

"Resources for Learning Science" will be the general theme for the four-day conference of NSTA and other science teaching societies of the AAAS opening in Cleveland, Wednesday, December 27. Mark C. Schinnerer, Cleveland superintendent of schools, will welcome participants at the first joint session on Wednesday morning at 10 o'clock.

Other joint sessions are scheduled for Thursday and Friday mornings. Separate sessions will be held each afternoon by NSTA, the American Nature Study Society, and the National Association of Biology Teachers. Conference headquarters will be at the Statler Hotel.

Highlights of the NSTA sessions include an earth-biological science program on Wednesday, a physical science program on Thursday, and the fourth national conference on industry-science teaching relations on Friday. There will be an organizational meeting of the new NSTA Business-Industry Section the evening of Friday, December 29. A Saturday morning symposium arranged by the AAAS Cooperative Committee on the Teaching of Science and Mathematics and an afternoon symposium on the National Science Foundation are recent additions to the program.

The AAAS annual science exposition is promised to be worth the trip to Cleveland in itself. The NSTA Committee on Apparatus and Equipment has also planned an exhibit to consist of science-teaching ideas, apparatus, and equipment.

Reservations may still be made for the conference by writing to Miss Louise D. Perkins, director, Cleveland Housing Bureau, 511 Terminal Tower, Cleveland 13.

The program for NSTA sessions and joint sessions of the conference follows. Sessions of other cooperating societies are included in the complete conference program which has been distributed to all NSTA members.

Wednesday, December 27

10:00-12:00 Joint Session of Science Teaching Societies, Grand Ballroom, Hotel Statler

Raymond Gregg, Presiding

Welcoming Address: Mark C. Schinnerer, Superintendent, Cleveland Public Schools

Symposium: Outdoor Resources for Learning Science

Panel Members

Joe Craw, Superintendent, New Castle City Schools, New Castle, Indiana

Ruth Hubbard, Supervisor, Cleveland Heights Schools, Cleveland Heights, Ohio

Richard L. Weaver, Director of Resource-Use Education, North Carolina Department of Public Instruction, Raleigh, North Carolina

Julian Smith, Supervisor of Health, Physical Education and School Camping, Michigan Department of Public Instruction, Lansing, Michigan

1:00 Opening of Exhibits of Science Teaching Materials (Continuing through Friday)

2:00-5:00 Session of NSTA, Euclid Ballroom, Hotel Statler

James W. Gebhart, Presiding

Utilization of the Physical and Biological Resources of the Ocean for the Teaching of Science

G. Francis Beaven, Research Biologist, Department of Research and Education, State of Maryland, Solomons Island, Maryland

Utilization of the Physical and Biological Resources of the Rocky Mountain Area for the Teaching of Science

John Johnson, Director of the Rocky Mountain Biological Laboratory, State Teachers College, Edinboro, Pennsylvania

Role of the Science Teacher in the Conserving of Outdoor Resources

Panel Members

Charles Dambach (Chairman), Chief, Division of Wildlife, Ohio State Department of Natural Resources, Columbus, Ohio

R. H. Eckelberry, Director, Conservation Laboratory, Ohio State University, Columbus, Ohio

John S. Richardson, Associate Professor of Education, Ohio State University, Columbus, Ohio

Edward C. Prophet, Associate Professor of Geography, Michigan State College, East Lansing, Michigan

8:00-10:00 The Fifth Annual Junior Scientists Assembly, Pine Room, Hotel Statler
An Activity of the AAAS

10:00-12:00 All-Societies Mixer, Grand Ballroom, Hotel Statler

Thursday, December 28

8:30 Projection of Science Teaching Films, Grand Ballroom, Hotel Statler

Maurice Bleifeld, Newtown High School, Queens, New York City

10:00-12:00 Joint Session of Science Teaching Societies, Grand Ballroom, Hotel Statler

Betty Lockwood, Presiding

Symposium: Human Resources for Learning Science

Developing a Science Program to Meet the Real Needs of Children

Frances Harwich, School of Education, University of Chicago, Chicago, Illinois

Developing Science Programs Around the Needs of People

Ernest E. Neal, Rural Life Council, Tuskegee Institute, Tuskegee, Alabama

Using Resource Agencies to Prepare Science Materials and to Train Leaders

Clyde A. Erwin, State Superintendent of Public Instruction, Raleigh, North Carolina

2:00-5:00 Session of NSTA, Green Room, Hotel Allerton

Robert H. Carleton, Presiding

Program Planning in the Physical Sciences

Planning for Effective Teaching by Radio in the Physical Sciences

Ben Levine, Science Broadcast, Station WBOE, Board of Education, Cleveland, Ohio

Planning for Desirable Teacher-Pupil Demonstrations in the Physical Sciences

Ernest O. Bower, Assistant Principal, East Technical High School, Cleveland, Ohio

Planning for Greater Cooperation Between Industries and the schools so as to Increase Interest in the Physical Sciences

Everett Hughes, Chief of Chemical and Physical Research Division, Standard Oil of Ohio, Cleveland, Ohio

Planning for the Guidance of Science-Talented Youth

E. G. Pierce, Former Instructor in Specializing Chemistry, East Technical High School, Cleveland, Ohio

8:00 AAAS Presidential Address, Grand Ballroom, Hotel Statler

The Science Teaching Societies will join with the AAAS for their Presidential Address and Reception

Friday, December 29

8:00-9:30 Planning Committee, Parlor M, Hotel Statler

Officers of the Science Teaching Societies and others interested will meet to plan for the 1951 joint sessions

8:30 Projection of Science Teaching Films, Grand Ballroom, Hotel Statler

Maurice Bleifeld, Newtown High School, Queens, New York City

10:00-12:00 Joint Session of Science Teaching Societies, Grand Ballroom, Hotel Statler

R. W. Lefler, Presiding

Symposium: Industrial and Technological Resources for Learning Science

Industrial and Technological Resources for Learning Science

G. E. Pendray, Public Relations Counsel, Pendray and Company, New York City

A Science Teacher Surveys the Possible Instructional Uses of Industrial and Technological Resources

Wayne Taylor, Head, Science Department, Denton Senior High School, Denton, Texas

Industry, Foundations, and Public Schools

Harold G. Bowen, Executive Director, Thomas A. Edison Foundation, West Orange, New Jersey

A School Administrator Looks at Outside Community Resources for the Teaching of Science

Harry E. Ritchie, Assistant Superintendent of Schools, Cleveland, Ohio

2:00-5:00 Fourth National Conference on Industry-Science Teaching Relations, Euclid Ballroom, Hotel Statler

(This program is sponsored by the Advisory Council on Industry-Science Teaching Relations of the NSTA)

Morris Meister, Presiding

Brief Presentation of Recent Studies in the Field
Warren Nelson, Director of Educational Research, Hill and Knowlton, Inc., New York City

Henry Liebschutz, Education Research, Inc., Washington, D. C.

Frank Smola, National Dairy Council, Chicago, Illinois

James C. Sinnigen, Pendray and Company, New York City

Panel Discussion

Discussion from the Floor

Future Prospects of Industry-Science Teaching Relations

Gilbert P. O'Connell, Department of Public Relations, General Motors Corporation, Detroit, Michigan

8:00 Fourth National Conference on Industry-Science Teaching Relations, Second Session, Ohio Room, Hotel Statler

Gilbert P. O'Connell, Presiding

Proposals for a Program of Work of the Business-Industry Section of NSTA

Saturday, December 30

10:00-12:00 AAAS Cooperative Committee on the Teaching of Science and Mathematics, Grand Ballroom, Hotel Statler

R. W. Lefler, Presiding

Symposium: Teacher Training and Teachers' Workshops

Industrial Teachers' Workshops in a University (The Westinghouse Experiment at MIT)

Francis W. Sears, Professor of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts

Industrial Teachers' Workshop (The General Electric Approach)

Leonard O. Olsen, Professor of Physics, Case Institute of Technology, Cleveland, Ohio

AEC National Laboratories and In-Service Training of College Teachers

Russell S. Poor, Chairman, University Relations Division, Oak Ridge Institute of Nuclear Studies, Oak Ridge, Tennessee

Lippincott

Science textbooks for your high school classes

Science For Everyday Use

by

Smith and Vance

A comprehensive one-year general science text for use in either eighth or ninth grade.

Biology For You

Revised

by

Vance and Miller

A basal high school biology text organized on the unit-problem plan. Includes an abundance of tests and activities.

Chemistry For The New Age

by

Carleton and Carpenter

A high school chemistry text written especially for high school students of today.

Physics For The New Age

by

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Books in Review

Play With Trees. Millicent E. Selsam. 62 pp. \$2.00. William Morrow and Company, Inc. New York. 1950.

The illustrations alone are worth the price of this fine, down-nearly-to-pocket-size book, and Fred Scherer does them in inkline that is clear and beautiful. Some of the winter trees are nakedly beautiful, and the detail of leaf-scars and opening buds is exquisite.

"How to grow your own trees," and "Pipelines in the Tree" start off five good chapters, written at about fifth-grade level. The reading difficulty is a bit above that, perhaps at grade eight or nine in places. However, the directions for many experiments are clearly given. How to plant, how to investigate the "feeding habits," how to discover the secrets of the new leaves, and the beginnings of the fruit are well told.

Keeping a record of leaves recognized and named can be done by spatter prints, crayon prints, or by dipping in hot paraffin, and all of these methods are described and illustrated. With the photographic process so common in children's lives, blue-printing or ozalid-printing might have been added.

This is one of the "Play With . . ." series, of which *Play With Plants* has already appeared.

JOHN G. READ
Boston University

Biology in Daily Life. Francis D. Curtis and John Urban. 608 pp. \$3.60. Ginn & Company. New York. 1949.

This new high school biology textbook provides abundant content for those whose biological training will terminate with high school, and it is sufficiently broad and complete to provide a good foundation for those who will study biology in advanced courses.

The organization is simple and logical. The materials are presented definitely and persistently to contribute to the development of the accepted objectives of biology for high school.

Special attention has been given to the vocabulary and style and the selection and definition of scientific and non-technical terms to facilitate reading comprehension. It provides materials and activities which make it easy to care for individual differences. An effort to enable the teacher to provide for individual differences is made through the use of questions and legends to stimulate reflective thinking about the illustrations. Essential materials have been designated. The scientific and non-technical vocabulary has been refined and explained. Varied and graded activities has been provided. Study aids, community activities, emphasis on biological topics in the news, bulletin board display suggestions, material for panel discus-

sions, and practical applications of biological principles are given to contribute to the objective of providing for individual differences.

The book is attractively illustrated by line drawings and pictures in sepia. Supplementary learning aids also are available. These include tests, a workbook, and a teacher's manual and key.

Little attention has been given, however, in this book to the integration of projected materials and to other modern teaching materials which are so essential to complete learning. The book is so designed that the workbook would be almost essential if the teacher carried out sufficient laboratory and field experiences to make the biology course what it should be. While this would be an asset for the teacher who can use the workbook wisely, it is definitely a shortcoming for the teacher who uses the workbook as a source of busy work.

HUBERT J. DAVIS
Norfolk County Schools
Portsmouth, Virginia

Song of the Seasons. Addison Webb. 125 pp. \$2.50. William Morrow & Company. New York. 1950.

The author, Addison Webb, is a member of the Council of New York Academy of Sciences. He recently was elected a Fellow of the Academy in recognition of his outstanding work toward the advancement of science. In this book he presents a free and easy style that children love.

Charm, accuracy, and humor are the key as the story of the seasons is told. "Springtime is the season for babies. Summer is the time for rest . . ." and in passing through the seasons we are given a vivid glance into the lives of the squirrels, opossums, bears, birds, raccoons, and many other animal friends that interest youngsters.

In spring the earthworms begin to plow the ground; living things push their heads out into the sunlight; birds return from their visit to the south.

In summertime, baby birds are taught to fly, baby otters learn to swim, and baby skunks become efficient "mousers." In all the animal world the young are taught how to live. As summer passes and autumn arrives, there is feasting. There is an abundance of food, and those members of nature going south must eat enough, or harvest enough, to last through the cold winter. When winter does arrive, all nature rests for the work of the year is finished.

The illustrations are gay and lively. They add much to the content, but the greatest charm of this work is the simple, humorous way in which Mr. Webb writes. We see a fine example in the way he describes the housing conditions of the raccoon. By winter time

"the raccoon has lived well and is fat. He moves into a tree hollow with his fat mate. If there is still room, he permits his fat children to move in, too. If there is still room, he is joined by his fat father and his fat mother."

This is a book that can be enjoyed by both young and old, and the only prerequisite necessary is a love of nature.

MILLARD HARMON
Newton Public Schools
Newton, Massachusetts

Cross Country—Geography for Children. Paul R. Hanna, Clyde F. Kohn. 160 pp. \$2.20. Scott, Foresman and Company. New York. 1950.

This beautiful book, the kind one has come to expect from this publisher, certainly is different from the one this reviewer learned geography from 30 years ago. It's different in lots of ways. Maps, both in color and in black and white, invite learning experiences; visual aids, numerous and intriguing, are sure to be fun for children to "find out" from; best of all, perhaps, is its full-length story—a *good* story all the way through. And nine-year-olds like stories.

But this reviewer looked at the book through the eyes of a science teacher. Are there *real* and natural, not forced, opportunities to bring science and social studies together in the elementary school? Judging by this book, the situation is more nearly one of de-

mand than opportunity. In fact, it might be said that without including numerous related science experiences, the teacher who uses this book only for social studies learnings is missing half her opportunities—and obligations. A few examples will illustrate. There is a chapter on "The Airport"; so let's find out more about gravity, how we use it and overcome it. While the Pages are motoring "Across the Desert," why not try to find out "What do plants need to grow?" A stop at "Hoover Dam" provides proper setting for an elementary study of dams and water pressure. Let's not stop with learning "How Mountains are Shown on Maps"; let's find out more about "How does the earth's surface change?" Other settings for introducing experimental science are found in the study of a thunderstorm, how farm and city dwellers get their water, river transpiration, coal mining, and at least a dozen more.

The book itself would seem to have all the appeal of a favorite "store bought" juvenile, and nine-year-olds are likely to enjoy it whether it's their school textbook or not. Interestingly, at the end of the story, the Pages arrive in Washington, D. C.—and start looking for a house. They like one in Washington and one in Virginia. Finally Mr. Page agrees with mother, "Let's buy the Virginia house. We won't give up our votes to save a thousand dollars."

ROBERT H. CARLETON
National Science Teachers Association

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Owls. Herbert S. Zim. 105 pp. \$2.00. William Morrow & Company, Inc. New York. 1950.

This is the seventh in a series of science picture books written especially for younger children. It is so attractive, interesting, and informative that adults also will appreciate it. The type is large, the language simple, and the style direct and pleasing.

Dr. Zim explains through simple narration and excellent illustrations the anatomy of the owl's skull, eyes, neck, head, ears, wings, feathers, and feet. The discussion of anatomy is so closely integrated with the functions of these organs, and the life habits, food habits, enemies, etc. so interestingly discussed that the owl takes on new significance in the mind of the reader.

Through the line drawings the big owl eyes create the illusion that they are almost human. The unusual qualities of the owl's eyes and their unusual sight both day and night are explained. Many misconceptions and superstitious ideas about owls are cleverly explored. The explanations of food and feeding habits are supported by scientific data. The book emphasizes the economic importance of owls.

The illustrations by Joy Buba in black and white make this another outstanding contribution to science literature for young and old.

HUBERT J. DAVIS
Norfolk County Schools
Portsmouth, Virginia

Sourcebook on Atomic Energy

Dr. Samuel Glasstone's *Sourcebook on Atomic Energy* is scheduled for release on December 4. Published under an exclusive contract with the Atomic Energy Commission, it is the authorized account of the past history, present status, and probable future of atomic science in peace, as well as war. Written as simply as a responsible book of science can be, it brings to the general public and to educators particularly an absorbing and completely authentic guide to every aspect of atomic energy.

Fully illustrated, the Sourcebook is listed at \$2.90. It is interesting to note that the royalty payments will go to the Atomic Energy Commission under its contract with the publisher, D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York City.

Safety Thru Elementary Science—a booklet of practical ideas and suggestions for using science experiences in the elementary school. Prepared and published jointly by the National Commission on Safety Education and the National Science Teachers Association. Order from NSTA, 1201 Sixteenth Street, N. W., Washington 6. (50c)

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Answers to DO YOU KNOW?

(From page 229)

1. 925 a minute.
2. 1 to 1.5 per cent.
3. Nearly $4\frac{1}{2}$ tons.
4. If kept cool and covered.
5. A week.
6. Quartzite.
7. 72,394.79 feet.
8. Albert Sauveur.
9. 10 cents to 40 cents.
10. A chunk of iron which solidifies in the bottom of a blast furnace.
11. Archigenes.
12. More than an hour.
13. The leptothrix.
14. Pennsylvania.
15. David and his sling.
16. By a tractor dozer weighing 93,000 pounds powered by a 750-H.P. engine.
17. Stadium was a measure of length about 606 feet; later a race course of that distance.
18. 5000 stitches a minute.
19. 6 to 8 months.
20. Formed by a rolling up and welding together of edges of flat steel strips.
21. Rameses II.
22. *Alligator*—a type of shear used to cut up scrap. Also a heavy scale which forms on chrome steel during reheating.

Salamander—the mass of solidified iron which gradually builds up in the bottom of a blast furnace.

Porcupine—a revolving cylindrical rack for cooling and inspecting galvanized sheet steel.

Monkey—a tap hole for drawing off slag from a blast furnace hearth.

Bug—small particle of steel which solidifies on the nozzle of a ladle for molten metal and thereby interferes with pouring.

Hen and Chickens—a method of casting whereby several molds are filled at the same time from a central trough or runner.

Glazed Pig—iron made brittle by high silicon content.

23. The upper and lower plates are polarized so that they tend to repel each other—but not enough to keep the mouth open.

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The new 512-page catalog just issued by the Central Scientific Company. It describes apparatus and supplies for secondary school science. Copies will be sent to school administrators and science instructors on official requests. Address Central Scientific Company, 1708 Irving Park Road, Chicago 13.

The 24-page Teaching Aids Catalog published by the Westinghouse Corporation. The catalog describes 80 free and inexpensive charts, posters, etc. covering numerous subjects, including atomic energy, jet propulsion, radio, nutrition, home freezing, lighting, and social studies. Junior and senior high school teachers can obtain copies by writing to the School Service Department, Westinghouse Electric Corporation, 306 Fourth Avenue, Box 1017, Pittsburgh 30.

The revised Westinghouse nuclear physics charts also published by School Service Department of Westinghouse. Measuring 25×37 inches and printed in two colors on heavy stock, they are suitable for wall mounting and a variety of instructional uses. The charts, together with an accompanying booklet, can be obtained for \$1.00.

The correlation chart for Young America Films for elementary school science. Revised and up-to-date, the chart shows the page-by-page correlation of the company's 26 films, produced under the guidance of Dr. Gerald S. Craig, with *all* leading textbooks for elementary science. Copies are available free upon request to Young America Films, Inc., 18 East 41st St., New York City 17.

Camping

(Continued from page 233)

to a village makes a good number. These villages are separated one from another so that a sense of isolation exists. There are five small tents, on movable platforms, serving two each, including counselors, and a fly for a cook tent.

The children draw rations from a central "store" and do most of their own cooking. They build a fireplace, improvise camp conveniences, keep up their own grounds, and plan much of their own program. At the end of the season the camp site is cleared and abandoned, and a new site is chosen for the next season.

There are central facilities for the use of all the villages. There is the "store" already mentioned. There is a dining tent or hall for the use of such groups as have been on long, tiring hikes or overnights. There is an infirmary and a library. There

Evaluation

(Continued from page 212)

planned five specific points for improving future class discussions. They were as follows:

(1) During the discussion carry in hand a list of the specific points which the discussion is expected to clarify.

(2) Carefully select from the students' discussion statements pertinent to the pre-formulated objectives and then persistently pursue them to a decision which is obvious to the majority of students. To accomplish this the teacher must plan definite ways of minimizing irrelevant remarks.

(3) Avoid making statements which bring about pupils' fixation in a manner which substantially reduces individual thought. In general, students are prone to seek clues as to what the teacher thinks is a correct response and, by the same token, avoid critical thinking. An example of a student responding to social pressure was found on Norman's end-test paper when he reversed his response to Mary's experiment. In reversing his response he wrote, "I say 'yes' because everybody else says so, but I still think the answer is 'no'."

(4) When introducing new topics, use a simple quiz which contains only two or three difficult concepts. Scrutiny of the discussion pointed out that the situation involving three experiments was a little too complex for the students to handle when the material was new to them.

(5) Refine the instructional test items by studying the student responses. As an example, student repetition and fixation on the idea that judges would have to remember how clean the teeth were could have been obviated by including in the experiments the idea that the judges recorded the results of their pre-examinations.

is a waterfront under suitable supervision. There is a handicraft center under supervision. Children from the different villages join on occasion for large scale activities such as council fires, barbecues, stunt nights, and parties.

This is a type of organization that lends itself well to school camping. We need to devise techniques for reducing the number of counselors used in most camps; probably one to eight children is the best we could hope for. And we need leaders with enthusiasm and vision; the school camps in New York State have succeeded as long as there were good leaders, and they have failed when no one replaced these leaders as they moved on. Perhaps science teachers will take up this challenge.

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Are ammoniated dentrifices effective in reducing dental decay? Researchers at the University of Illinois College of Dentistry have recently reported the results of a two-year study involving 716 grade school children in Peoria. Findings showed that an ammoniated toothpowder is more effective in reducing decay activity than a non-ammoniated dentrifice.

Three types of dentrifices were used: one containing the cleaning agents that are commonly used in dentrifices; a so-called ammoniated dentrifice which contained five per cent ammonium phosphate and three per cent carbamide; and a third similar to the second but with bentonite, a colloidal clay, added with the possibility that it might prolong the retention of ammonia on the teeth.

Results of the use of these three dentrifices were compared to a control group which were allowed to brush the teeth according to the usual habits. These children did not participate in supervised classroom brushing.

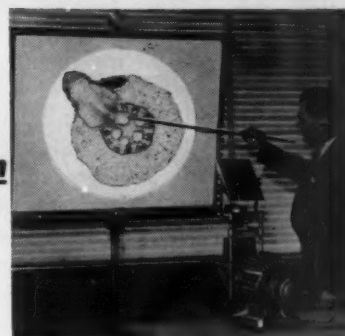
Children in the three dentrifice groups brushed their teeth at their desks at the beginning of the classroom period each morning and afternoon. They were asked to continue the brushing after each meal at home.

A clinical and x-ray survey of all children at the end of the two-year study indicated: (1) Those who used the ammoniated dentrifice without the bentonite experienced the least dental decay. The percentage of teeth attacked in this group was 20.5 per cent less than for those children in the control group who brushed their teeth according to their usual habits. (2) The non-ammoniated dentrifice was less effective. Youngsters who used this toothpowder had 9.3 per cent fewer cavities than the control group.

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Your officers and dozens of committee workers have given many hours of "borrowed time" to make these achievements possible. They appreciate such expressions of approval and confidence from members. They believe that the NSTA program is

helping *every* science teacher in the nation, and they believe that it deserves the support of every science teacher. Which brings us to the point of this little piece:

There is nothing we need so much right now as 2000 new members. Since we now have 6000 members, we could achieve this goal if one in three would sign up one new member.

Use the application form on this page. Do it now, within the next two weeks. Nearly all the nation's 62,000 science teachers have seen our Packet XIV which also contained a copy of our October journal. Now is the time to sign them up—while NSTA is fresh in their minds. It's the follow-up that pays dividends. Will you be one of the "one in three" who does get a new member for NSTA?

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When Foreign Science Teachers Meet

How does a science teachers' meeting in a foreign country compare with those typically American. Here is a brief account of such a meeting held last April 26-28 at the University of Poitiers, France, and relayed to NSTA by Professor F. Buresté. We think it will be of interest to many.

"Intended primarily for the benefit of secondary school teachers, the purpose of the sessions was twofold: (a) to summarize in simple form the extraordinary developments in physics and chemistry, both theoretical and experimental, that have taken place in the last few decades, and (b) to study the most effective means of adapting contemporary physics and chemistry to secondary education.

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